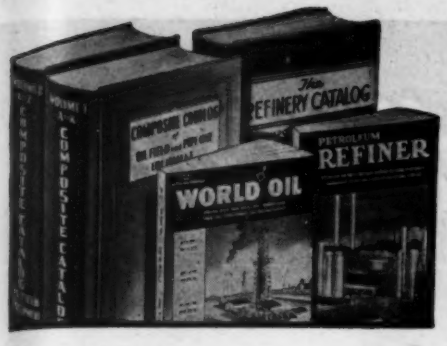

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for the refining-natural gasoline industry

WORLD OIL (formerly The Oil Weekly)
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for the drilling-producing-pipe line industry

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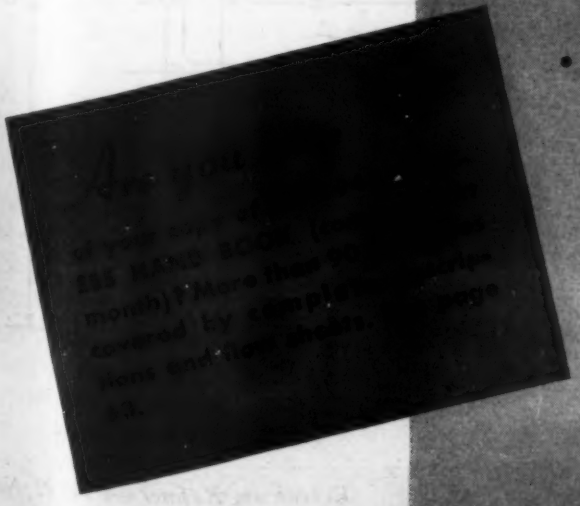

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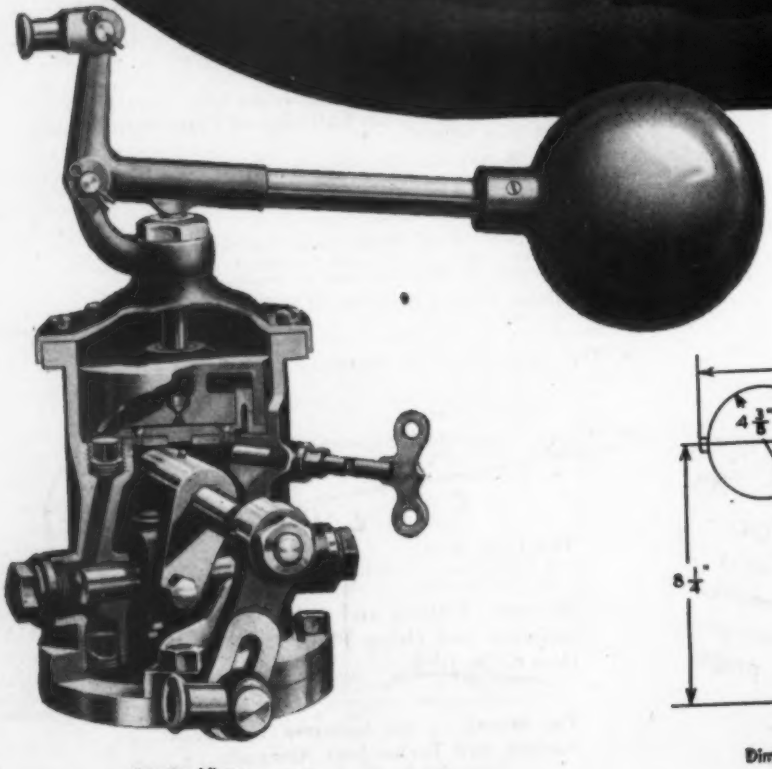

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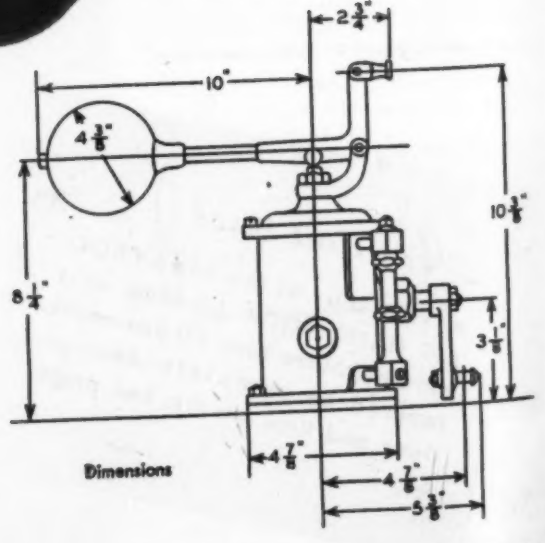

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VOLUME 27, NO. 8 AUGUST, 1948

PETROLEUM
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A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

CAPITALISM or Communism? That is the choice we are offered now.

Capitalism may be defined as an economic system in which the ownership of land and natural wealth, the production, distribution, and exchange of goods, the employment and reward of human labor, and the extension, organization, and operation of the system itself are entrusted to and effected by private enterprise and control under competetive conditions. We have first hand knowledge of how well this system works. Maybe it misses perfection, but it has provided us with the highest standard of living and the maximum degree of personal freedom that the world has known.

Little Room For Argument

Communism may be defined as any theory or system of social organization involving common ownership of the agents of production, and some approach to equal distribution of the products of industry. As a theory, the system may have its points, but in actual practice it doesn't work out so well. We all have at least a general knowledge of the living standards of the Russians, and some ideas on just how much personal freedom they enjoy.

For a milder practical example a little closer to home, we may well recall the complexities and annoyances that we experienced not long back with food, tire, and gasoline rationing. That was a wartime necessity, but even in times of ample supply, any government attempt to regulate "the equal distribution of the products of industry" must be an inefficient, clumsy arrangement, well wrapped in red tape. Only thus could any degree of fairness be approached, and the over-all result is such that all who must depend on the distribution will suffer. Non-competitive operations have little incentive toward efficiency.

Each step that we take now in allowing increased government control of the works carried on in the past through private enterprise brings us just that much nearer a situation in which all the acts of our lives will be regulated for us in about the same fashion that the government regulated our food purchases a little while back!

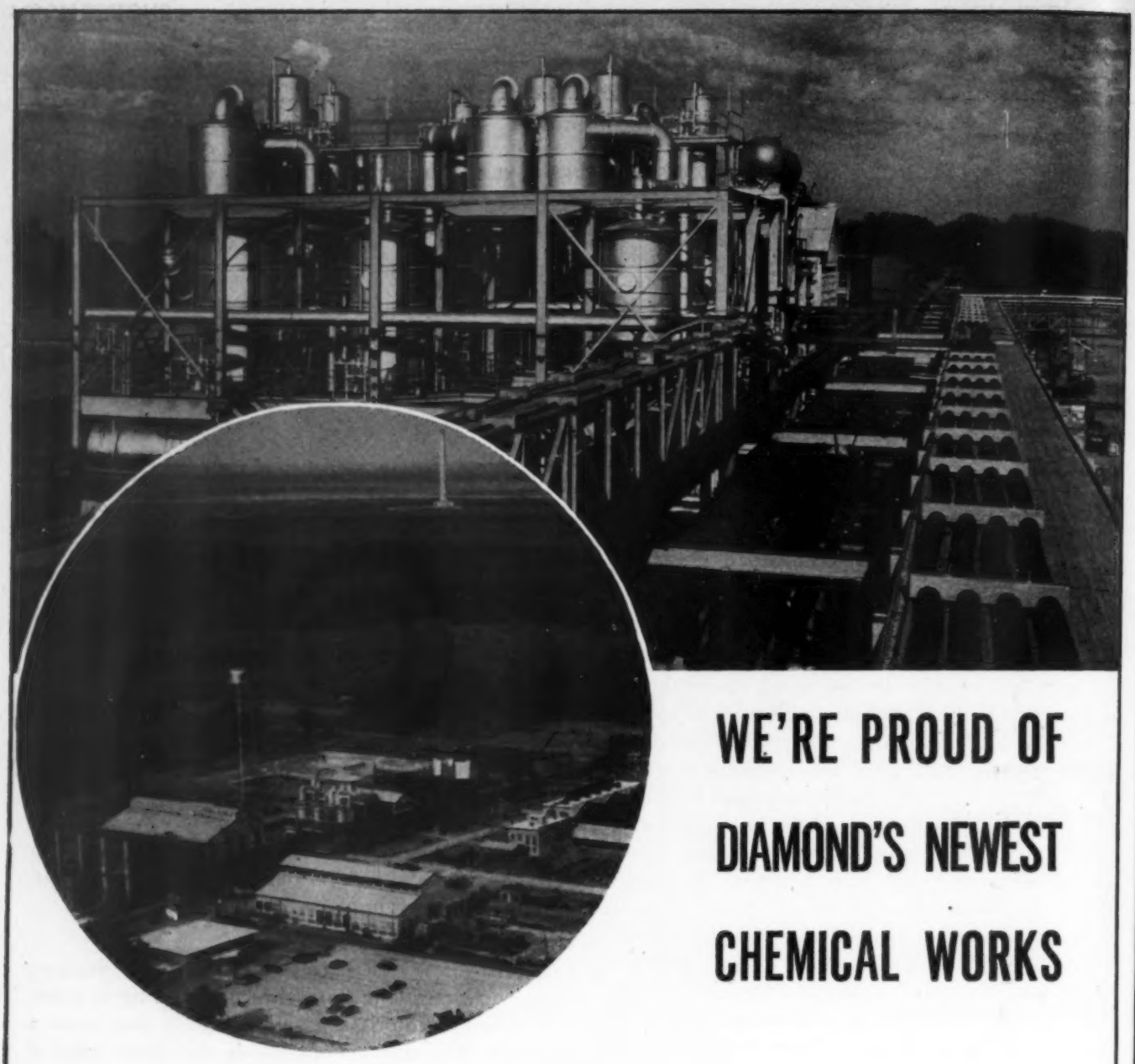
SERVE-YOURSELF gasoline filling stations are sweeping southern California, offering to price-conscious motorists a saving up to five cents a gallon. The stations operate on the simple idea of minimum gasoline prices and low overhead achieved by volume sales and by letting the customers wait on themselves.

Development In Filling Stations

First of the new stations opened some eleven months ago and since then perhaps 95 other "gas-a-terias" have appeared along the most heavily traveled routes in Los Angeles County. A city ordinance keeps them outside the city limits on the grounds that they are a fire hazard.

A spot check of service stations in Los Angeles shows that some of the new models are selling as much as 500,000 gallons a month, that the average range is between 100,000 and 300,000. A conventional service station, despite attendants to mop windshields and fill tires, is considered doing well to sell 25,000 to 30,000 gallons of gasoline a month.

A survey of 1000 people, made by a major oil



WE'RE PROUD OF DIAMOND'S NEWEST CHEMICAL WORKS

Diamond Alkali Company's newest chemical plant, the Houston Works on the Houston Ship Channel, recently went on stream, manufacturing chlorine and caustic for what it's able young president, R. F. Evans, so aptly described as "the living, growing, expanding chemical industry." Brown & Root, Inc. are proud to have been selected for engineering and construction of this great plant—proud of the part we have in the process industry in the Southwest, which is fast securing its position as a world chemical capital.

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company, in the Long Beach area where a number of "serve-yourselfs" are concentrated, shows 13 percent now patronize the new stations and almost all said that it was because of the low price. Some large companies that invested heavily to sell people on the benefits of filling station service are without doubt keenly interested in this new development.

Silicone Plant In Operation

A MULTI-MILLION dollar chemical plant for the manufacture of silicone materials has been placed in full commercial operation by the Chemical Department of the General Electric Company after about a year of partial operation. The war-developed materials will be processed in form of rubber, greases, oils, and water-repellents, to meet the increasing demand by industry for silicones.

Derived from sand and processed by a completely new form of chemistry, silicone materials are noted for their ability to withstand a wide range of temperatures from approximately 70° below 0° F. to 520° F. above. The silicone rubber is being applied primarily as gaskets for a host of industrial products such as capicitators, jet and gas turbine engines, baking ovens, lighting fixtures, and high vacuum systems.

Interest In Nitrogen Removal

IMPROVEMENTS of great interest to many sections of the oil industry are being made in methods for handling and processing nitrogen-rich natural gases.

Many pipe lines are transporting natural gases containing 10 percent or more of non-combustible nitrogen. Large reserves of natural gas have been developed in some areas which have been limited because of the low heating value resulting from high nitrogen contents. Removal of a large part of the nitrogen from this natural gas would greatly increase the present capacity of these pipe lines enabling them to carry more natural gas of higher heat value.

The United States Bureau of Mines and the American Gas Association have undertaken a cooperative study of the removal of nitrogen from natural gas. More than $100,000 will be spent on a project intended to increase transmission capacity of natural gas pipe lines and to improve marketability of natural gas containing non-combustible nitrogen.

The Bureau of Mines is interested in nitrogen removal because of its close association with operating problems at the Bureau's helium plants. The American Gas Association has undertaken this project as one phase of an expanded research program ($1.8 million to be spent in three years) on the problems of gas production and utilization.

Detailed studies of physical and chemical means of removing nitrogen from natural gas have been made. A nitrogen removal pilot plant unit has been completed permitting test runs. The Bureau of Mines is sponsoring a special meeting at Amarillo, Texas, on August 16-17 for engineers of gas companies and others interested in this problem. The purpose of the meeting at Amarillo is to permit engineers to obtain greater familiarity with the technical and economic phases of the problem and the prospective means for its solution, particularly by liquefaction and fractionation. An opportunity will be offered at one of the sessions for engineering contractors and others to present information and proposals on nitrogen removal plants.

War Product Aids Furnace Stokers

RESEARCH projects have a persistent habit of paying-off in ways not anticipated by the researchers. This phenomena is illustrated once more by a development promising a considerable commercial market for a petroleum product developed for a highly specialized military task.

Application of thickened fuel—a wartime development that provided a more effective fuel for flame throwers and incendiary bombs—as an industrial product that will aid power generation, has been reported by Esso Standard Oil Company.

The product is a fuel igniter made of thickened diesel oil that will fire stoker-fed industrial boilers to full operating steam pressure in 30 minutes compared with eight hours usually required by wood and coal kindling. Reduction of the time required for a full head of steam eliminates the need for stand-by emergency fires and effects substantial savings in coal consumption.

Employing the same thickening agent, an aluminum soap, as in the war material, the fuel igniter has a semi-fluid, jelly-like consistency and can be applied in nests along the boiler grate well in advance of use. The thickened fuel clings to the coal, burns slowly and with sufficient intensity to fire the coal. A paper torch can be used to ignite the fuel. Its ability to fire the entire furnace evenly contributes to the speed with which steam pressure is obtained. In tests, five gallons of the product were used to fire boilers capable of producing up to 500,000 pounds of steam per hour.

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SUBSIDIARY OF ROCKWELL MANUFACTURING CO. EAST CHICAGO, INDIANA

Diesel Fuel Additives

M. SMOLAK and F. L. NELSON
Research and Development Department,
Socony-Vacuum Laboratories, Paulsboro, N. J.

TESTS SEEK EVALUATION OF ADDITIVES FOR IMPROVING THE COLD STARTING CHARACTERISTICS OF DIESEL FUELS

THE COLD weather starting of automotive high speed type diesel engines has been and still is a problem in the field of transportation. This problem is not limited to the frigid areas of the Far North where the military services have been experimenting but exists in the Continental United States wherever winter temperatures fall below 30° F.

Original presentation of the accompanying treatment was before the 113th meeting of the American Chemical Society, Chicago, April 19-23, under the title "The Evaluation of Additives and Blends for Improving the Cold Starting Characteristics of Diesel Fuels."

THE diesel is a compression-ignition engine, meaning that fuel ignition is obtained from the heat of compression of the intake air charge. When the initial intake air temperature is too low, the final compression temperature is not sufficient to effect ignition of the fuel. Present diesel engines are so designed that they are unable to start with conventional (40 to 60 cetane number) diesel fuels below temperatures of approximately 15° F. without auxiliary starting aids. The starting aids currently resorted to include such practices as idling all night, electric jacket water heaters, flame primers, glow plugs, ethyl ether, etc., all of which are either costly from the operating or maintenance standpoint or are inconvenient to use.

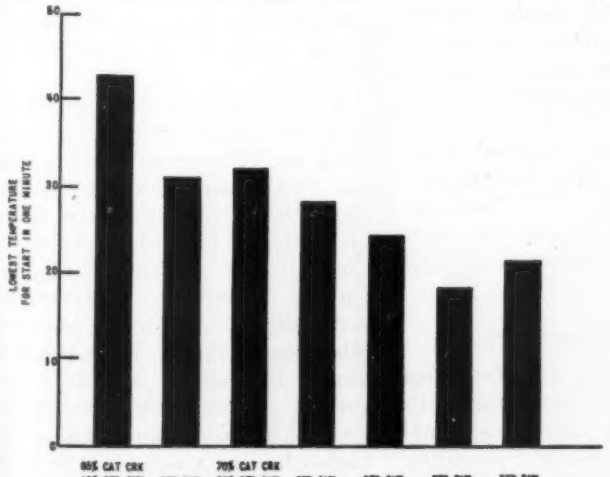
There are many factors which have a bearing on the ability of a diesel engine to start in cold weather, however the three items of prime importance are: 1) The ability to obtain sufficient cranking speed, 2) combustion chamber design, and 3) fuel characteristics.

The ability to obtain sufficient cranking speed has, for the most part, been largely attained through the use of high-viscosity index lubricating oils and efficient 24-volt starting equipment.

Only meager information is available on the effect of engine combustion chamber characteristics on cold starting. There is an urgent need for information on this phase of the cold starting problem, information which can best be obtained by engine builders.

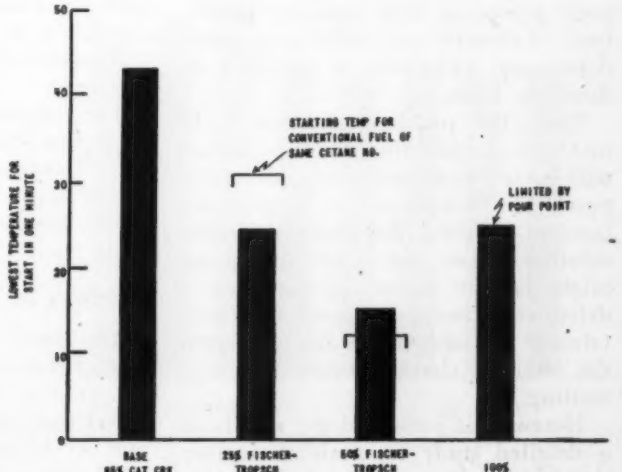
In contrast, the effect of fuel characteristics on cold starting has been studied extensively with the general

TABLE 1
Cold Starting Characteristics and Properties of Conventional Diesel Fuels

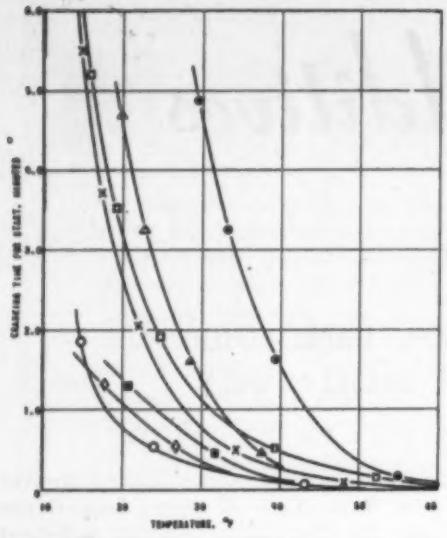


FUEL	85% CAT CRK 15% STR RUN	STR RUN	70% CAT CRK 30% STR RUN	STR RUN	STR RUN	STR RUN	STR RUN
CRUDE TYPE	MIXED	CALIFORNIA	MID-CONT	MID-CONT	MID-CONT	MID-CONT	MID-CONT
CETANE NO.	36	40½	46	51	53½	56	66
GRAVITY, °API	29.3	33.6	35.0	39.7	41.0	42.8	38.8
ASTM Dist. °F							
IBP	410	395	380	350	340–	342	370
10%	462	437	431	417	401	400	444
50%	512	487	499	490	480	451	534
90%	600	582	588	595	594	509	592
EP	650	648	647	680	804	546	610
POUR PT., °F	-5	-20	-10	-10	-35	-40	0
VIS @ 100°F, SSU	37	35	35	37	35	34	35
FLASH, °F	175	-	-	-	-	166	-
CAR RES (10% BOT)	0.1	0.04	-	0.05	0.04	0.02	-

TABLE 2
Cold Starting Characteristics of Blends with Fischer-Tropsch Synthetic Fuel Oil



FUEL	BASE 85% CAT CRK 15% STR RUN	25% FISCHER-TROPSCH 75% BASE	50% FISCHER-TROPSCH 50% BASE	100% FISCHER-TROPSCH
CETANE NO.	36	46	62	95
GRAVITY, °API	29.3	35.0	40.4	52.0
ASTM DIST, °F				
IBP	410	395	372	370
10%	462	443	437	427
50%	512	497	494	488
90%	600	585	580	575
EP	650	634	631	628
CLOUD PT., °F	+8	+14	+16	+28
POUR PT. °F	-5	0	10	+25
VIS @ 100°F, SSU	37	36	36	-
FLASH, °F	175	-	-	-



LEGEND

	Cetane No.	Boiling Range, °F.	Crude Type	Process
●	36	410–659	Mixed	85% Cat Crk 15% Str Run
□	40½	395–649	California	Str Run
△	46	380–647	Mid-Continent	70% Cat Crk 30% Str Run
■	50½	340–606	Mid-Continent	Str Run
×	51	350–660	Mid-Continent	Str Run
○	54	342–546	Mid-Continent	Str Run
◊	56	370–610	Mid-Continent	Str Run

FIGURE 1
Temperature vs. Cranking Time to Start Engine with Conventional Diesel Fuels.

realization that certain inherent shortcomings exist. Needless to say an adverse relationship exists between cetane number and pour point. Low pour point diesel fuels are usually naphthenic in type with poor ignition quality, whereas diesel fuels of high ignition quality are usually paraffinic in type with high pour points. There is little that can be done to improve pour points of high ignition quality fuels. Currently available pour point depressants have little or no effect on distillate fuels.

Since the problem resolves itself into one of obtaining proper ignition with fuels which have satisfactory pour points but lacking in low temperature ignition quality, the most desirable solution from the fuel standpoint might be one where the customer is delivered a low pour point fuel containing an additive which imparted the desired characteristics for cold starting.

Herewith is presented the results of a detailed study to establish further the relation between diesel fuel characteristics and their cold starting ability in a full scale engine and to evaluate the effect of various ignition promoters on cold starting ability.

Laboratory Test Procedure

A 3-cylinder, 2-cycle engine of a type which is popular in the truck and bus field was set up in a laboratory cold room properly equipped. By thermostatic control of electric heaters and circulation of refrigerant, any desired engine temperature between 0 and 80° F. could be produced. In order to obtain better control and more rapid chilling, the coolant liquid was circulated through a radiator and back through the engine by an external pump during shut down periods. To avoid wide variations in the cranking speed of the engine, the battery was placed outside the cold room in a constant temperature location so that, by using 16 of the 24 volts available to the starting system, a constant cranking speed of 190 ± 10 rpm was obtained for all tests.

The engine was chilled to the desired temperature in about 3 hours and held at the test temperature for 1 hour. At the end of this time the throttle was set at the wide open position and the engine cranked continuously until the engine fired and continued to run under its own power. If the engine failed to fire after five minutes of cranking a "no start" was recorded.

After each start attempt, the engine was switched to a standard laboratory fuel and operated for a period of 15 minutes at which time the engine was switched to the next test fuel for a period of 5 minutes in order to flush out the fuel system. The engine was then shut down and chilled to the next test temperature.

The fuels and blends studied in this work were all evaluated on the basis of one minute cranking time since various sources recommend that cranking time in the field should not exceed 15 seconds to one minute due to the drain of current on the battery and overload on the starting motor and relay.

The starting data obtained were plotted as "Starting Time in Minutes" vs. "Temperature in °F." and the values of lowest temperature for start in one minute were derived from such plots.

Effect of Fuel Characteristics

The fuels evaluated for the effect of fuel characteristics on starting ability were a) blends of conventional diesel fuel stocks of normal volatility, and b) blends of a Fischer-Tropsch high cetane number synthetic fuel with a conventional refinery stock.

The starting characteristics of conventional diesel fuels are presented in Figure 1 as plots of temperature versus starting time. Figure 2, which was derived from Figure 1, is a plot of minimum starting temperature versus cetane number for one half and

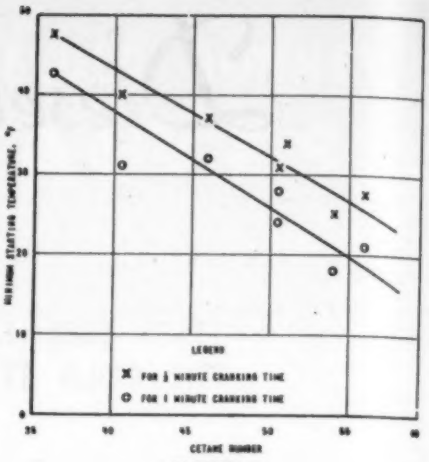


FIGURE 2
Relationship of Cetane Number to Starting Temperature for Conventional Diesel Fuels.

one minute cranking periods. Also, for conventional diesel fuels, as presented in Table 1, are fuel inspection data and bar graphs showing lowest temperature for start in one minute.

It appears for the most part, that minimum starting temperature decreases in direct proportion to increasing cetane number. As can be seen in Figure 2, a 10 cetane number increase in fuel quality will effect about a 12° F. reduction in the minimum starting temperature. It is also noted that in this range of 35 to 60 cetane number, which is the present range for commercial fuels, the lowest temperature permitting starting is about 15° F. to 25° F. depending on the cranking time. Although this work did not include fuels of conventional composition beyond the commercial range, other investigators[1] have shown that further increases in cetane number are of no value, the curve leveling out to about 15° F. beyond 60 cetane number.

Two of the fuels did not fall in line with the cetane number correlation. First, the 40½ cetane number straight-run fuel from California, crude was equal to or better than the 46 cetane blended fuel of Mid-Continent origin. There is no reasonable explanation for this discrepancy. However, similar occurrences have been reported by other investigators. The second deviation is that of the 54 cetane number kerosine which started somewhat easier than the 56 cetane number fuel of higher boiling range. As will be shown in more detail later, this is probably an effect of fuel volatility.

The cold starting characteristics of blends with a Fischer-Tropsch fuel are shown in Table 1. The 100 percent Fischer-Tropsch fuel of 95 cetane number was limited in starting to +25° F. because of its relatively high pour point. Blends of Fischer-Tropsch with a conventional refinery base stock pro-

duced starting in line with cetane number, but even these combinations were on the verge of being limited by cloud points at which temperature wax crystals could cause filter clogging.

Presented in Figure 3 are plots of cetane number versus pour point for what is perhaps the entire range of commercial stocks. The best combinations of high cetane number and low pour point are indicated by the lower boundary curve. This curve shows that for conventional refinery stocks, abnormally high cetane number fuels will have high pour points. Thus, even if fuels of higher cetane number could be made available, they would be limited by pour point in so far as cold starting is concerned.

Effect of Various Ignition Promoters

The blends evaluated for effect of additives on cold starting ability were a) blends of certain volatile compounds with a conventional refinery stock (physical aspect) and b) blends of a conventional refinery stock with compounds containing nitrogen, oxygen and sulfur and with certain miscellaneous compounds (chemical aspect).

The starting characteristics of a 36 cetane number base stock blended with 10 percent by volume of n-heptane, M-4 (20 octane number) reference fuel, iso-octane and ethyl ether respectively are presented in Table 3. These data indicate that while the base stock and blends with n-heptane, M-4 and ethyl ether were approximately of the same ignition quality, the starting characteristics improve in direct relation to the increase in front end volatility.

In contrast, the blend containing isooctane having the same volatility characteristics as the n-heptane blend, would not start even at a temperature of 50° F., indicating that the ignition quality of the volatile material is of major importance.

The small cross brackets on the vertical bars indicate the starting temperature for a conventional fuel of the same cetane number. It will be noted that the blends with n-heptane, M-4 and ethyl ether all start at temperatures below those which would have been predicted from cetane number alone.

The effects on cold starting of adding various nitrated compounds to the same 36 cetane number base stock are presented in Table 4. Nitrated compounds have been used experimentally with some degree of success for improving the ignition quality as defined by the CFR cetane number. The data indicate that 2,2-dinitropropane, amyl nitrate and n-butyl nitrate have no significant effect on the cold starting characteristics of the base stock even though these compounds effect substantial increases in cetane number.

The blends with n-butyl nitrate appear to impart some slight improvement to the starting ability of the base fuel but, as will be noted, increases in the concentration of this additive beyond 0.2 weight percent have no increasing effect on the base fuel.

Organic peroxides had varying effects on the startability of the base fuel as shown in Table 5. Both t-butyl hydroperoxide and cumene hydroperoxide increased cetane number appreciably but provided only slight increases in cold starting ability. Propylene oxide on the other hand showed no measureable improvement in cetane number but did exhibit a limited

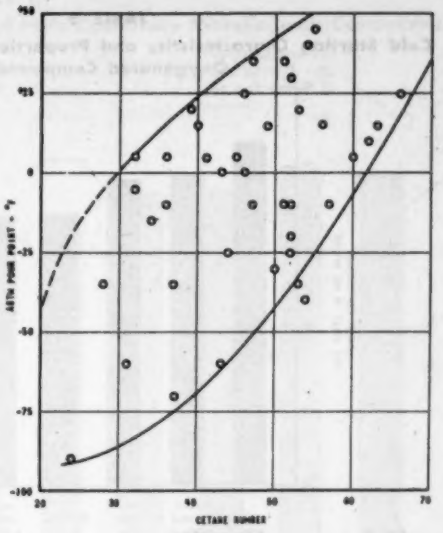
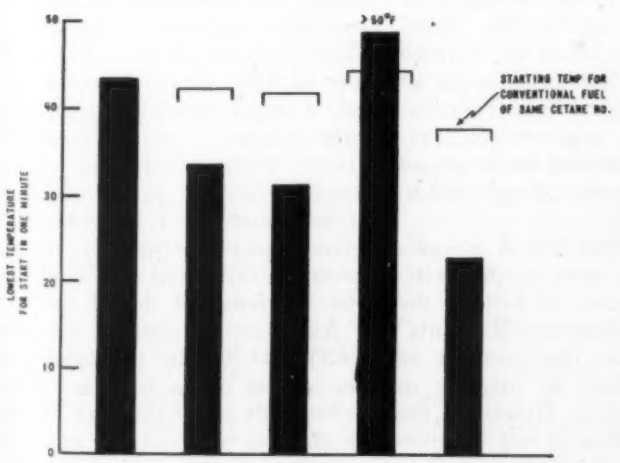


FIGURE 3

Relationship of Cetane Number and Pour Point of Distillate Fuel Oils.

TABLE 3

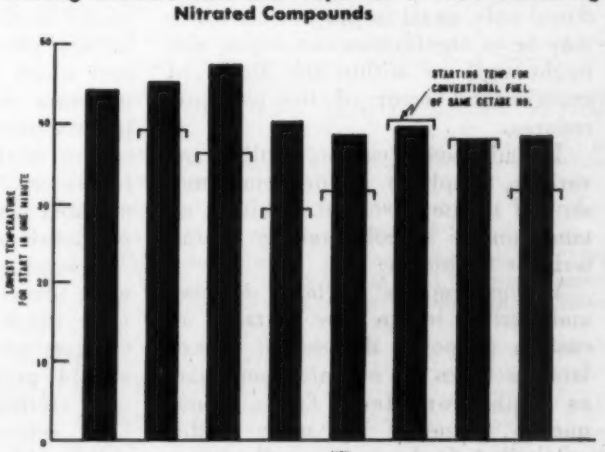
Cold Starting Characteristics and Properties of Volatility Blends



ADDITIVE	NONE	n-HEPTANE	M-4 REF FUEL	ISO-OCTANE	ETHYL ETHER
EMPIRICAL FORMULA	-	C_7H_{16}	-	C_8H_{18}	$C_4H_{10}O$
VOL % ADDITIVE	-	10	10	10	10
CETANE NO.	36	37	37½	33	41½
GRAVITY, °API	29.3	33.7	37.0	32.9	31.8
ASTM DIST, °F					
IBP	410	210	172	210	104
10%	462	323	290	325	170
50%	512	501	488	510	508
90%	600	590	591	598	600
EP	650	648	650	656	654
POUR PT., °F	-5	-	-15	-5	-5
V/I @ 100°F, SSU	37	-	36	36	36
FLASH, °F	175	-	-	-	-
GAS RES (10% BOT)	0.1	-	0.07	0.08	-

TABLE 4

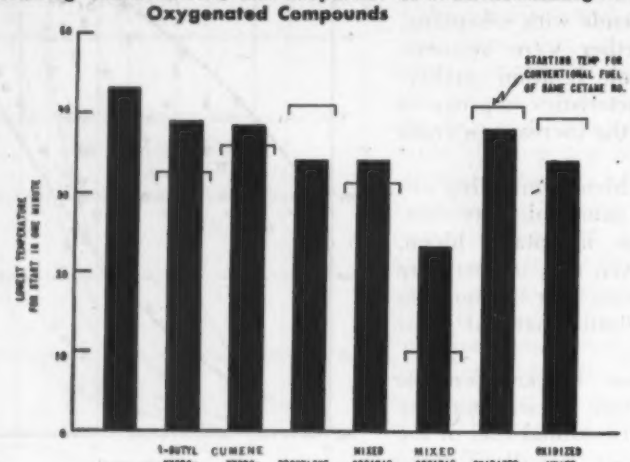
Cold Starting Characteristics and Properties of Fuels Containing Nitrated Compounds



ADDITIVE	NONE	2,2-DINITROPROPANE			AMYL NITRATE	n-BUTYL NITRATE		
EMPIRICAL FORMULA	-	$C_3H_6N_2O_4$			$C_5H_{11}NO_3$	$C_4H_9NO_3$		
WT % ADDITIVE	-	0.2	0.5	1.0	1.0	0.2	0.5	1.0
CETANE NO.	36	40½	43	48½	47	39	41½	47
GRAVITY, °API	29.3	28.6	28.5	28.3	28.3	28.6	28.6	28.6
ASTM Dist °F								
IBP	410	336	330	340	275	400	394	340
10%	462	472	470	468	462	476	476	476
50%	512	510	520	520	510	510	514	520
90%	600	602	604	604	600	606	602	602
EP	650	646	652	650	650	648	648	646
POUR PT., °F	-5	0	5	0	-5	0	0	5
V/I @ 100°F, SSU	37	37	37	37	37	38	37	37
FLASH, °F	175	-	-	-	-	-	-	-
GAS RES (10% BOT)	0.1	0.3	0.8	0.5	1.9	0.0	1.1	0.7

TABLE 5

Cold Starting Characteristics and Properties of Fuels Containing Oxygenated Compounds

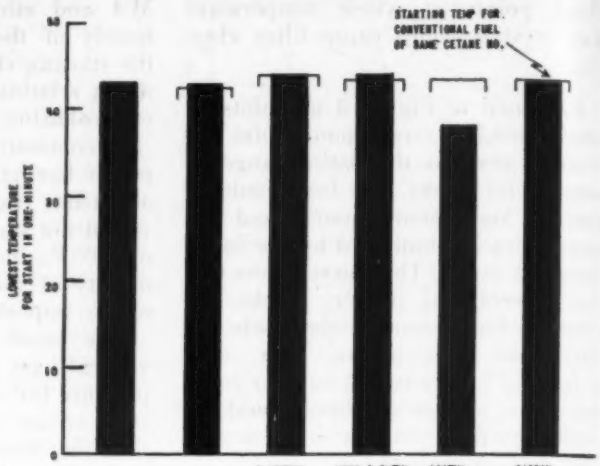


ADDITIVE	NONE	t-BUTYL HYDRO-PEROXIDE	CUMENE HYDRO-PEROXIDE	PROPYLENE OXIDE	MIXED ORGANIC PEROXIDES	MIXED ORGANIC PEROXIDES	OXIDIZED KEROSENE	OXIDIZED WHITE MINERAL OIL
EMPIRICAL FORMULA	-	$C_8H_{10}O_2$	$C_9H_{12}O_2$	C_3H_6O	995 $C_7H_{14}O_2$	995 $C_7H_{14}O_2$	-	-
WT % ADDITIVE	-	1.0	1.0	1.0	2.0	5.0	5.0	5.0
CETANE NO.	36	48	48	37½	47*	48	37	39½
GRAVITY, °API	29.3	29.0	28.5	30.4	-	30.0	30.3	31.3
ASTM DIST.°F								
IBP	410	210	380	137	-	195	367	194
10%	462	462	466	448	-	460	467	439
90%	512	500	520	500	-	490	500	490
90%	600	502	606	591	-	595	587	594
EP	650	634	654	648	-	634	634	670
POUR PT.°F	-5	-5	0	-5	-	-10	-10	-15
VIS @ 100°F, SSU	37	37	38	36	-	-	-	-
FLASH, °F	175	-	-	< 66	-	75	179	75
CAR RES (10% BOT)	0.1	0.0	0.0	-	-	-	-	-

*INTERPOLATED VALUE

TABLE 6

Cold Starting Characteristics and Properties of Fuels Containing Sulfur



ADDITIVE	NONE	THIOPHENE	3-METHYL THIOPHENE	MONO-t-BUTYL THIOPHENE	ACETYL THIOPHENE	CARBON DISULFIDE
EMPIRICAL FORMULA	-	C_4H_4S	C_5H_6S	$C_8H_{12}S$	C_6H_6OS	CS_2
WT % ADDITIVE	-	1.0	1.0	1.0	1.0	2.0
CETANE NO.	36	36½	34	36½	36½	36½
GRAVITY, °API	29.3	29.9	29.9	29.9	29.7	29.9
ASTM Dist. °F						
IBP	410	312	383	400	402	170
10%	462	451	442	445	447	451
50%	512	502	500	500	501	500
90%	600	592	567	590	590	588
EP	650	650	644	645	647	646
POUR PT. °F	-5	-10	-10	-10	-10	-10
VIS @ 100°F, SSU	37	37	37	-	37	37
FLASH, °F	175	148	168	182	184	186
CAR RES (10% BOT)	0.1	0.09	0.09	0.05	0.1	0.1
WT % SULFUR	0.11	0.41	0.38	0.32	0.31	-

tendency toward improving starting.

Mixed organic peroxides produced increases in both cetane number and cold starting ability but even here a concentration of 5 percent did not improve starting beyond the range obtainable with existing commercial fuels.

Additions of an oxidized kerosine and an oxidized white mineral oil produced only small improvements which may be of significance but which also might well be within the limits of experimental error of the test procedures.

The addition of carbon disulfide and various thiophene sulfur compounds showed no improvement in either cetane number or cold starting characteristics (Table 6).

Various reports of both domestic and German origin have on many occasions proposed the use of miscellaneous types of organic compounds as dopes for diesel fuels. Consequently, some of the more readily available of these or similar compounds were blended into the base fuel with the results shown in Table 7 for the following materials: diethylene glycol mono-methyl ether, diethylene glycol mono-ethyl ether, diethylene glycol di-ethyl ether, diglycerol, methyl formate, copper naphthenate, allo-ocimene and piperylene.

A 10 percent addition of diethylene glycol di-ethyl ether was the only additive in this group which produced an increase in the cetane number of the blend, yet all of the additive materials appear to have improved to some extent the starting characteristics of the base fuel.

In the case of the blend with copper naphthenate it might be pointed out that this material has been used in the laboratory to promote instability in gasolines. It may be that this compound contributed to the formation of certain peroxides, etc. in the diesel fuel which did not effect an increase in cetane number but did provide an improvement in startability. This reasoning might also apply to the performance of the oxidized kerosine and oxidized white mineral oil referred to previously in Table 5.

It must be admitted that it is somewhat unusual that most of the materials which happened to fall in the category of "Miscellaneous Materials" should produce an improvement in cold starting without an increase in CFR cetane number. However, the validity of these data is not in question inasmuch as the data were obtained over a period of 3 months, the individual runs being intermingled with the runs discussed previously.

Correlation of Test Data

From the foregoing presentation of data it is evident that "diesel dopes" as such have only a small effect on the starting characteristics of fuels in a full-scale engine. It is also apparent that cetane number as determined by the CFR ignition delay method bears no relation to the cold starting characteristics of these additive containing fuels.

In an effort to learn whether there is some simpler method than cold room testing for determining starting characteristics, critical compression ratio data were obtained on several doped and conventional fuels which had been evaluated in the cold room. These data are given in Figure 4 as a plot of CFR Cetane Number vs Critical Compression Ratio. Since this curve shows a good correlation of critical compression ratio with cetane number (in the range of 35 to 55 cetane number) it is evident that no correlation exists between critical compression ratio and the cold starting characteristics of doped fuels.

Autogenous ignition temperatures (ASTM D-286-30) were also obtained for several of the test fuels which resulted only in a "shot gun" pattern in so far as correlation with centane number or cold starting is concerned. These data are shown in Table 8. The limited data indicate that a correlation might exist with the three non-additive fuels.

Conclusions

The conclusions which can be drawn from the data obtained are as follows:

1) For non-additive fuels of con-

ventional composition and volatility, an increase of 10 cetane numbers lowers the permissible starting temperature about 12° F. The lowest temperature at which this particular engine would be expected to start without starting aids is about 15° F. even when using premium grade kerosine type fuels.

2) The addition of certain volatile materials to diesel fuel will improve starting ability at low temperatures provided the volatile material has a good ignition quality. Normal heptane is an example of an effective material while equally volatile iso-octane impairs starting ability.

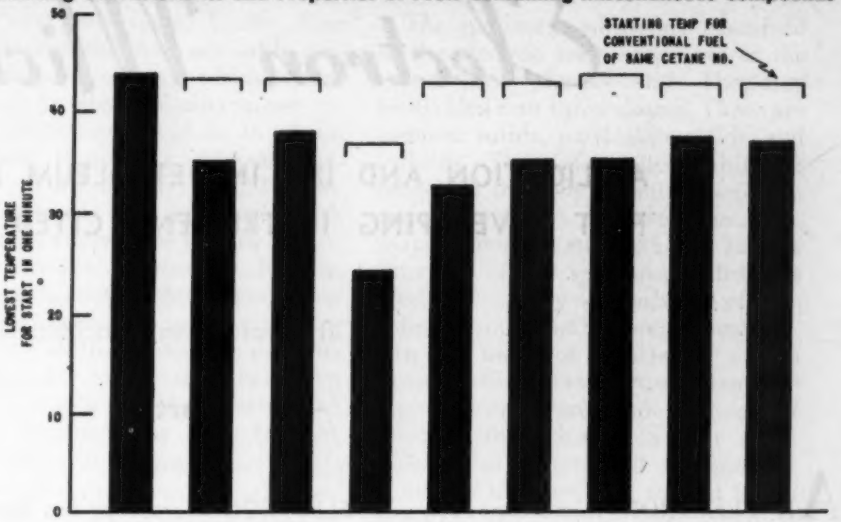
3) None of the chemical additives tested in this particular engine materially improve the cold starting characteristics of diesel fuels when used in concentrations of less than 10 percent even though CFR cetane number is increased by the use of some of these additives.

4) It appears that some additives may improve starting ability without affecting the cetane number of the base stock.

5) The cold starting characteristics of the doped fuels do not correlate with CFR cetane number, critical compression ratio or spontaneous ignition temperature.

TABLE 7

Cold Starting Characteristics and Properties of Fuels Containing Miscellaneous Compounds



ADDITIVE	NONE	DIETHYLENE GLYCOL MONO-METHYL ETHER	DIETHYLENE GLYCOL MONO-ETHYL ETHER	DIETHYLENE GLYCOL DI-ETHYL ETHER	DIGLYCEROL	METHYL FORMATE	COPPER NAPHTHENATE	ALLO-OCIMENE	PIPERYLENE
EMPIRICAL FORMULA	-	$C_5H_{12}O_3$	$C_6H_{14}O_3$	$C_8H_{18}O_3$	$C_6H_{14}O_5$	$C_2H_4O_2$	-	$C_{10}H_{16}$	C_5H_8
WT % ADDITIVE	-	2.0	2.0	10.0	5.0	1.0	1.0	1.0	1.0
CETANE NO.	36	35	35½	42½	36	36½	34½	36½	36
GRAVITY, °API	29.3	30.0	29.8	29.9	30.2	30.3	30.1	30.4	30.7
ASTM DIST, °F									
IBP	410	396	388	363	400	398	404	398	170
10%	462	448	444	419	450	450	450	444	452
50%	512	502	501	491	502	504	501	500	502
90%	600	589	590	583	585	593	588	598	589
EP	659	648	649	643	630	647	642	643	644
POUR PT., °F	-5	-10	-5	-10	-5	-15	-5	-5	-10
VIS @ 100°F, SSU	37	36	36	36	-	36	37	36	36
FLASH, °F	175	184	180	172	178	84	170	178	82
CAR RES (10% BOT)	0.1	0.1	0.1	-	-	-	-	-	-

Expenditure Unattractive

The general conclusion which can be drawn from this work is that the expenditure of effort to find a diesel dope (as thought of in the usual sense —0.2 to 1.0 weight percent concentration in the fuel) for improving cold starting is unattractive. This is especially true upon considering the results which can be obtained by the vaporization of certain starting aids directly into the induction air system of the engine immediately prior to cranking. By this means other investigators[1,2,3] have shown that diesel engines may be started at temperatures as low as —40° F.

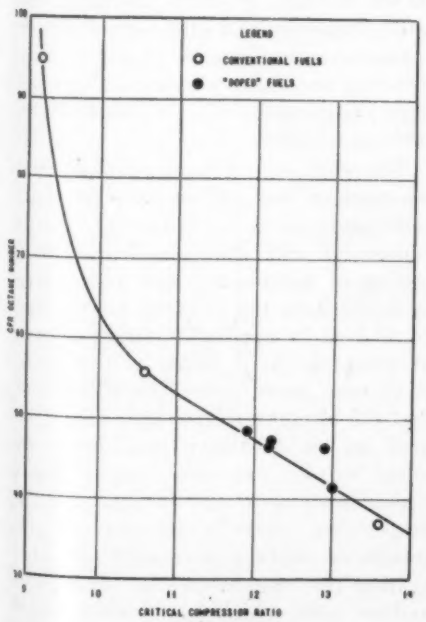


FIGURE 4

Relationship of Critical Compression Ratio and CFR Cetane Number for Conventional and "Doped" Diesel Fuels.

Many materials have been tried experimentally for this purpose among which were ethyl disulfide, amyl nitrate, chloropicrin and ethers. Of these ethyl ether promises to be the most practical, and was used to some extent by the British military services during the war.

Danger of Explosion

One disadvantage accompanying this procedure is the hazard of an engine explosion resulting from the improper use of the ether. Thus, with the necessity for using a carburetor or equivalent metering device in order to utilize ether safely, this technique constitutes a certain nuisance which places it in the same category as the electric heaters and all night idling previously mentioned. However, by this means, cold starting can be achieved in locations where engine heating facilities are not available and idling all night is not practical; whereas with doped fuels starting cannot be obtained.

ACKNOWLEDGEMENT

The authors acknowledge with grateful appreciation the cooperation and assistance of Mr. R. E. Albright, Mr. L. Raymond and Mr. H. J. Vander Straeten.

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[2] "Cold-Starting Tests on Diesel Engines" H. R. Porter, SAE Journal, Vol. 51, 1943, p. 356.

[3] "Cold-Starting of Diesel Engines" P. H. Schweitzer, Diesel Power and Transportation, October, 1946.

TABLE 8

Autogenous Ignition Temperature, CFR Cetane Number and Cold Starting Characteristics of Conventional and Doped Diesel Fuels

	FUEL	Autogenous Ignition Temp. °F.	Minimum Starting Temp. with One Minute Cranking Time °F.	CFR Cetane No.
A	85% Catalytically Cracked..... 15% Straight Run.....	695	43	36
B	Fuel A + 10% Ethyl Ether.....	690	23	41½
C	Fuel A + 1% Amyl Nitrate.....	690	39	47
D	Straight Run.....	620	22	56
E	Fuel A+1% 2, 2-Dinitropropane.....	585	40	48½
F	Fuel A+1% n-Butyl Nitrate.....	560	39	47
G	Fischer-Tropsch.....	550	25*	95

* Limited by pour point.

Electron Microscopy

APPLICATION AND USE IN PETROLEUM INDUSTRY OF THIS FAST DEVELOPING INSTRUMENT CITED IN 2-PART SERIES

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(Part I)

ELECTRON microscopy has developed sufficiently in the last 15 years to have a literature of its own. Texts 1, 2, 3, (see references) are suitable both for non-specialist, and for the prospective specialist within the subject. There are also extensive bibliographies 4, 5, 6, 7 of the work done up to 1945, a perusal of which will show the wide applications of the electron microscope. Available texts are, however, deficient in two respects: a) There is not an up-to-date and comprehensive description of the techniques of electron microscopy. b) The problems, faced by a scientist outside the field who may wish to apply the electron miroscope or its results, or by a laboratory director who may wish to judge the desirability of setting up an electron microscope section within his laboratory, have received little attention. This article attempts, in an introductory manner, to fill this gap, with more particular reference to the hydrocarbon processing industry. It may also serve as a review for electron microscopists already working in this field.

AN ELECTRON microscope consists of the following parts:

1) An illuminating system which produces a beam of electrons and directs this beam upon the material to be examined.

2) A specimen stage by which the mounted material may be moved about so that suitable regions can be chosen for study.

3) An imaging system which takes the electrons leaving the specimen and forms a highly magnified image which may be seen on a fluorescent screen at the bottom of the microscope.

4) A camera which will provide a permanent record of the highly magnified images. The micrographs shown in this article are made by further photographic enlargement from the plates obtained from the microscope.

5) A vacuum system. Since electrons are easily scattered by air, the microscope is continuously evacuated during operation. A valve system is provided so that the specimen and photographic plate can be inserted and the microscope brought to an operating vacuum quickly.

6) Power supplies to accelerate the electrons and energize the lenses. In the instruments most commonly employed in this country the electrons are focused by the magnetic fields of specially designed electromagnets. The power supplies have to be very stable if clear and stationary images are to be produced.

Figure 1A shows the external appearance of the RCA Model EMU Microscope (Electron Microscope-Universal). Figure 1B shows a simplified cross section of such an electron microscope and Fig. 1C, in a simplified manner, the ray paths through the microscope.

The specimen produces a visible image on the fluorescent screen of the microscope by the process of electron scattering. The thicker or more dense regions of the specimen scatter electrons so that they are unable to pass through the imaging system. The corresponding parts of the image are, therefore, deficient in electrons and appear darker on the flouresoent screen and in positive photographic prints.

The microscope in wide general use in this country is the RCA Model EMU which will operate at magnifications between 200X and 20,000X and can also be used for electron diffraction studies. Under ideal conditions it will yield micrographs that can be enlarged usefully to 200,000X. It is designed for use as a general research instrument. Another instrument is the RCA Model EMC, a small console model, operating at fixed magnifications of 500X or 5000X but capable of producing micrographs that can be photographically enlarged to 100,000X. It is designed as a simpler, less expensive microscope for more limited applications, such as quality control in colloidal products and production checking.

General Considerations

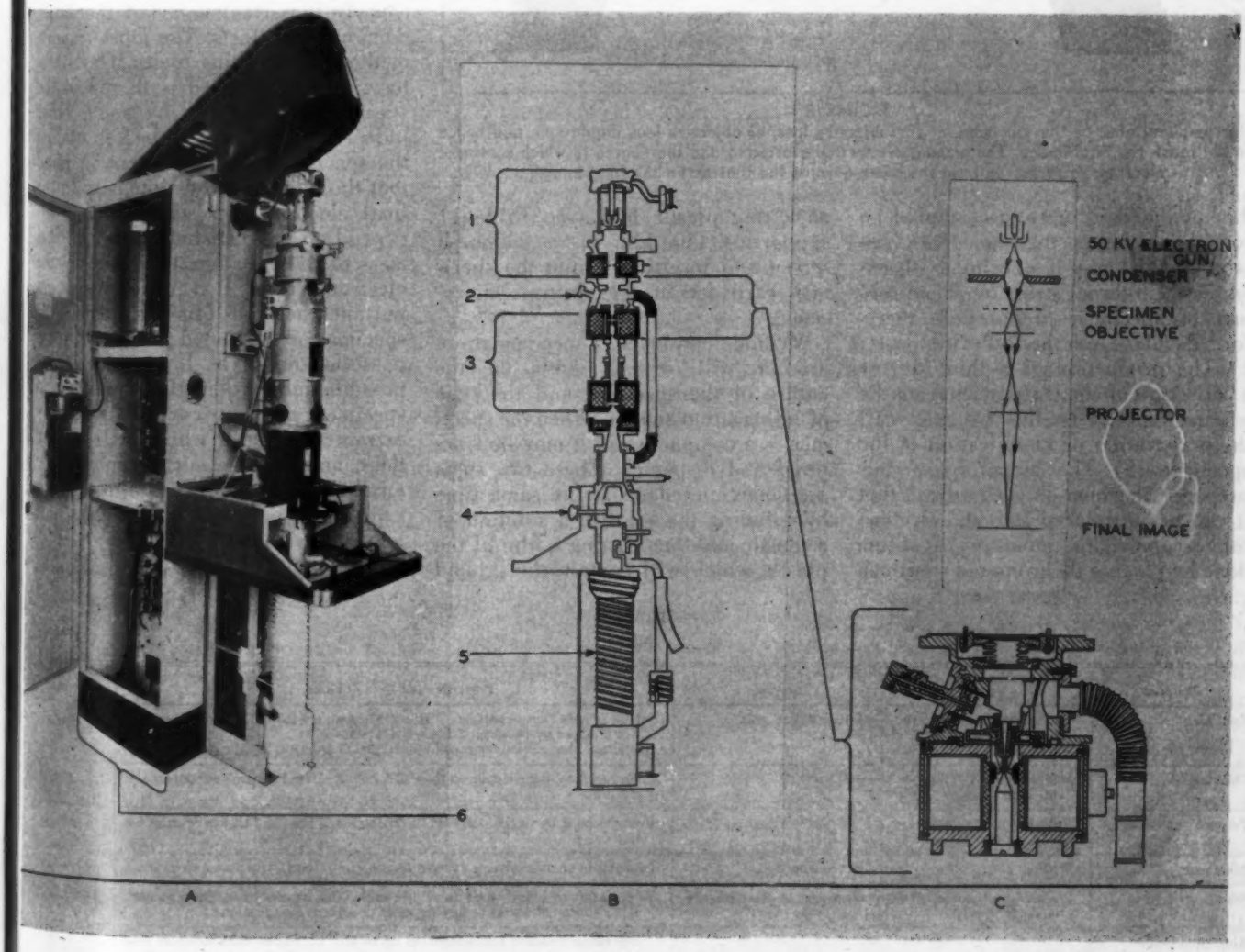
The fundamental reason for the wide, and increasing, use of the electron microscope is to be found in its high resolving power. The best light microscopes are unable to resolve details in a specimen smaller than approximately 2000 °A (i.e., 0.2 microns or 2×10^{-5} cm). The electron microscope will usually resolve details smaller than 100 °A and with some samples will resolve 10 °A. It is because this range of size, 2000 °A to 10 °A includes so many powders, colloids, catalysts, and other structures of commercial importance that the electron microscope is playing an increasingly important role in research on such materials.

The early work with the electron microscope was exploratory in character and was to a considerable extent concerned with the elaboration and testing of techniques, and an attempt to decide how the electron microscope could best be applied to existing lines of research. As a result of this work it is now more generally recognized that the electron microscope should be used as an auxiliary instrument. In other words, one does not perform experiments *with* the electron microscope, but uses it to observe the results of other experiments. By permitting the research worker to see the system with which he is working, it helps him to interpret the results of his experiments and to design, intelligently, further experiments on the sys-

tem under study. This aspect of the use of the electron microscope will be referred to again when we come to consider examples of its applications.

Electron microscopy in an industrial research laboratory poses its own personnel problems. The minimum personnel for efficient operation of an electron microscope laboratory is one research worker with graduate training or its equivalent, and one technician with experience in photographic work. The research worker should have, ideally, experience in electron microscopy and also in the field in which the laboratory is engaged. It is almost impossible to find one man with both qualifications, and difficult at present to find one with the former alone. In view of the technical nature of the work and the varied problems it will pose, even in one laboratory, a man with sound basic training, preferably in physics, is recommended. The output from institutions which provide experience with electron microscope in their graduate schools, such as the University of Toronto, University of Michigan, and the Massachusetts Institute of Technology, is limited, and can hardly be expected to meet the demand of the next two years. Under these circumstances, the most advisable procedure for an industry which wishes to set up an electron microscope research laboratory would be to obtain a physicist, if possible with some experience in the industry's field of research, and give him six months with the electron microscope to gain experience in electron microscopy. Routine examinations and quality control using an EMC microscope would not require such highly skilled personnel, once the procedures for examination had been set up. It will be found that when the research program has been brought into operation and samples are available for observation in the electron microscope, the microscopist's problem falls into three parts. These are successively: specimen preparation, the microscope examination with the production of micrographs and the interpretation of the micrographs. While in practice, these form integrant parts of the complete examination, they are described separately in the following sections.

The specimens which are examined in the electron microscope are in the vast majority of cases solids. They may be divided into three classes. These are compact solids, particulate solids, and colloids. The information which is sought in the electron microscope examination may concern the size, shape, internal structure or surface structure of the specimen. When the specimen consists of a mixture of particles, the information sought may concern the mode of association of the particles. Since the electron beam employed in the electron microscope will penetrate through only a very small thickness of material, it is necessary to modify the specimen so that it can be spread out into the form of a thin film or a collection of thin particles, so that it may be penetrable to the electron beam; unless, of course, one is prepared to examine the specimen in silhouette, or study internal surfaces by the replica technique. As a rough general rule, the specimen when prepared should be less than 1 micron in



View of RCA Model EMU electron microscope. Hood raised, covers and control panel removed.

Center section diagram of EMU microscope.

Ray paths in electron microscope.

FIGURE 1

—Photos Courtesy RCA.

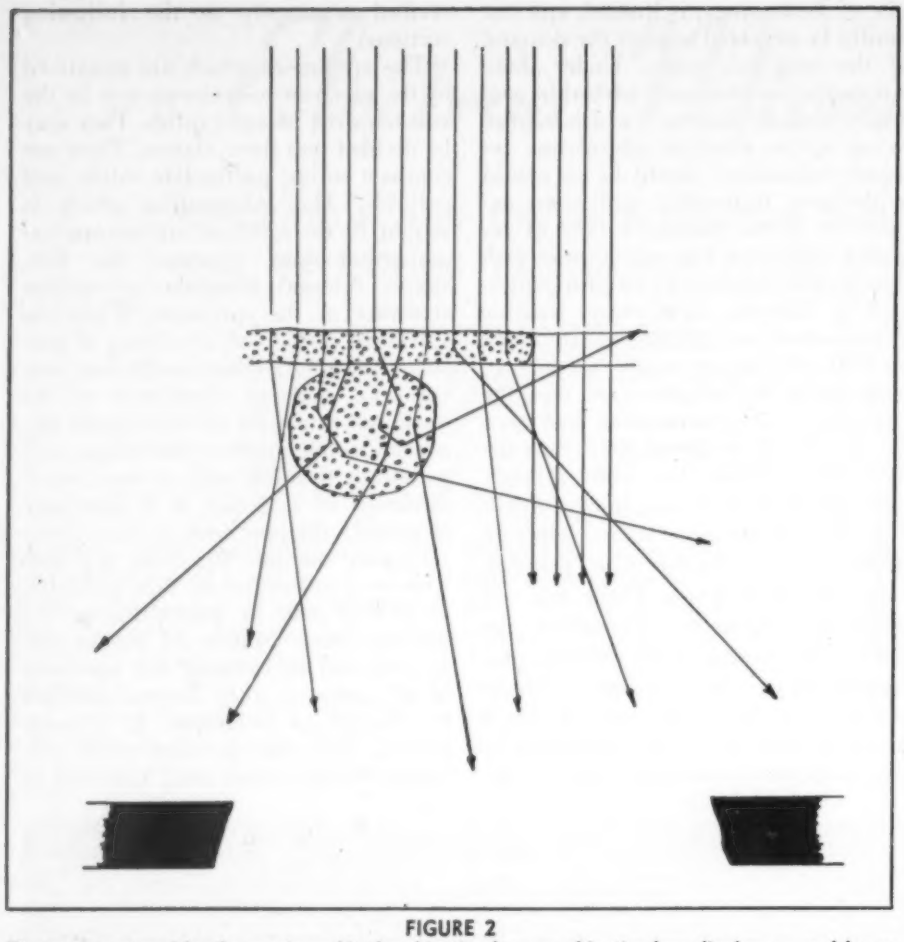


FIGURE 2

Electrons scattered by the specimen hit the objective lens, or objective lens diaphragm, and hence do not reach the final image. The amount of electron scattering and the degree to which scattered electrons are removed from the beam governs the contrast in the final image.

thickness and in most cases should be considerably less than one-tenth micron in thickness if one hopes to examine the internal structure. The problem of specimen preparation, therefore, devolves into the following parts: 1) The production of a thin film or a collection of small particles from the original specimen; this we may call the preparation or modification of the specimen. 2) The mounting of this prepared specimen in such a form that it can be introduced into the electron microscope. This mounting is often done by placing the prepared specimen on a thin plastic film (see Table 1) supporting this film on a 200-mesh screen and inserting it into the specimen cartridge of the electron microscope.

Methods employed in specimen preparation will depend both on the nature of the specimen and the type of information sought. When the specimen is a compact solid it may be fractured and dispersed. These two steps are sometimes done at the same time by grinding the solid in a solution of a plastic and then casting a film of the plastic which will contain the ground and dispersed solid[9]. There are now available microtomes[13] which will produce sections of solids less than one micron thick. It is too early to judge the general usefulness of these microtomes.

If one requires information on the surface structure of a compact solid, this can often be obtained by making a replica of a solid surface in a thin film of plastic. There are many ways available for making such replicas[14]. In general they will yield information on the surface structures of the solid down to dimensions of the order of 100° A. If the sample is particulate, for example a pigment—the problem of specimen preparation is then, in general, one of dispersing the sample and maintaining it dispersed during the process of specimen mounting. Finally, in the case of colloidal suspensions the problem is one chiefly of specimen mounting. A colloid is generally in a sufficient state of dispersion and the problem of specimen mounting is largely one of maintaining this dispersion.

In specimen preparation it is extremely important to avoid the introduction of artifacts. The most reliable method for checking to see if artifacts have been introduced is to repeat the specimen preparation by some other independent method. When mounting the specimen it must be kept in mind that the distribution of intensity in the final electron microscope image will depend on the distribution in the total mass of the specimen traversed by the electron beam. It is, therefore, important that the film on which the specimen is mounted be as thin as possible and of as low a density as possible and further, that the film and specimen are not covered with any extraneous debris which will reduce the contrast in the micrographs. Some auxiliary techniques for improving the contrast in electron micrographs will be discussed later.

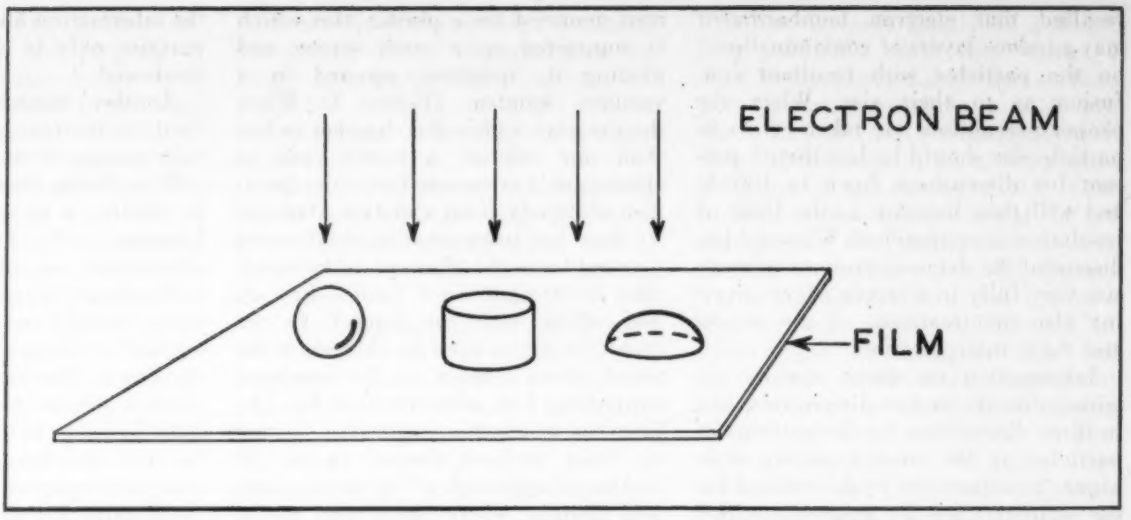
A light microscope examination of

TABLE 1

Films

Material	Source	Solvent	Properties and Uses of Films	Reference
Formvar	Shawinigan Products Corp. "Formvar 15-95"	Ethylene dichloride. Dioxane	Soluble in most organic solvents. Has weak resistance to dilute hydrochloric acid. Not attacked by benzene. Films soften at 120-130° C. Used as support and for replicas. Shows pebbly or rope-like structure of order 100° A when shadowed.	8 and 9
Collodion	Mallinekrodt "Parlodion"	Amyl acetate	Films have properties similar to those of formvar. Used for specimen support and replicas.	9
Petrex 5	Hercules Powder Company		Recommended by Gabor. Method of production of films and their properties not stated.	3 page 51
Alkathene	Du Pont	Hot xylene	Insoluble in organic solvents at room temperature. Inert. Has coarse structure.	10
Silica	Prepared by evaporation onto polystyrene or other plastics in vacuo.		Temperature resistant. Used for replica work. Can be used as specimen support. When shadowed, shows pebbly structure of polystyrene (plastic).	11
Aluminum Oxide			Temperature resistant and amorphous up to 400° C. Shows more structure than plastics.	2—p. 245
Aluminum Beryllium	Prepared by evaporation onto collodion films in vacuo. Collodion subsequently dissolved away.		Temperature resistant. Can be used in 20° A thicknesses. May contain high percentage of oxide. Used as specimen supports.	12

FIGURE 3



the unmounted specimen will often be useful in suggesting the best methods of specimen preparation to be employed. When the specimen has been mounted, a further examination in the light microscope under dark, field illumination will, in experienced hands, serve as a check on the efficacy of the specimen preparation.

Examination

When a specimen has been placed in an electron microscope it is usually examined visually at low magnification as a final check on the specimen preparation. Suitable fields having been chosen for microscopy, the magnification is then increased by increasing the strength of the projector lens and the chosen fields are photographed. It is perhaps worth emphasizing that a careful visual examination of the specimen will often yield information which could not be readily recorded on a photographic plate. For example, a film may break and the specimen turn over so that it can be observed from a new direction and information obtained on its shape in three dimensions. The majority of pictures are taken by the light-field electron microscopy. That is, the images are formed by the unscattered, or very little scattered, electrons by the process described above.

It is also possible to produce dark-field images in the electron microscope. In this method a diaphragm is employed to remove from the electron beam, leaving the specimen those electrons which have not been scattered so that the final image is formed only by scattered electrons. Some dark-field micrographs have been published by Levy[15] and more recently by Hall.[16] The methods evolved by Hall, which are particularly applicable to small crystalline specimens, are likely to increase the usefulness of the dark-field method of observation.

Due to the considerable depth of field of the electron microscope, it is possible to take stereoscopic pictures with it. When one picture has been taken, the specimen is tilted through a small angle (approximately 4° to 12°) and then a second picture is taken. When the two pictures are viewed in a stereoscopic viewer, a three-dimensional effect is produced. This method has its greatest use when the specimen has considerable depth, of the order of 100 microns, in the direction in which the electron beam is moving. This is true, for example, in the case of some smokes mounted directly on a wire mesh and examined in the electron microscope. By viewing a stereoscopic pair in the type of stereoscopic viewer employed in aerial mapping, it has been found possible to make measurements in the third dimension and this has been employed in some replica studies.[17] The shadow-casting method to be described later provides approximate measurements in the third dimension much more readily and is, therefore, more commonly employed. The stereoscopic method works best when the difference in levels to be observed are greater than 50 microns. Where the differences in levels are less than one micron, shadow-casting must be used.

Interpretation

The main point to be kept in mind in interpreting electron micrographs is that if one part of the specimen is in focus, then usually all of the specimen will be in focus because of the great depth of field. For this reason the sphere, cylinder and lens-shaped particles shown in Figure 3 would each give a circular image. The resulting ambiguity in interpretation must be continually kept in mind, particularly if the observer has become used to interpreting light micrographs. Methods of removing these ambiguities will be described later. Another ambiguity in electron micrographs is due to the fact that a darker part of the image may indicate either a denser or thicker part of the specimen. Since thicker parts of the specimen will cast longer shadows, this ambiguity can now be removed by the shadow-casting technique. Finally, it should be mentioned that electron diffraction by crystals in the specimen may lead to special intensity distributions in the image.[16] The interpretation of an electron micrograph should lead to information on the size, shape and structure of the specimens.

Measurements of size and size distribution presuppose that the magnification of the electron microscope has been determined. This can be done most accurately if a specimen, previously calibrated in the light microscope, is photographed in the electron microscope. Replicas of diffraction gratings provide very suitable specimens for this purpose. Accurate calibrations at magnifications of approximately 500X, 2000X, 5000X, 10,000X and 20,000X will be adequate for almost any problem that may be encountered. In both the magnification calibration, and in the subsequent reattainment of a given magnification, the lenses of the microscope should be brought to a standard magnetic state by switching them off and on several times. The specimen must also be inserted at the correct distance from the objective lens. This will be indicated by the objective current (or dial settings) for most exact focus if the hysteresis of the lens is removed. The magnifications chosen for standardization should be at the upper ends of the available magnification ranges to minimize distortion[18] which would otherwise lead to considerable errors in particle size distributions. The focus in the micrographs should be exact[19] since errors of the order of 50°A in particle diameter can be made in measurements on out-of-focus images. Finally, in accurate work it must be

recalled that electron bombardment may produce layers of contamination[20] on the particles with resultant confusion as to their size. When the proper precautions are taken errors in particle size should be less than 5 percent for dimensions down to 100°A, and will then increase as the limit of resolution is approached. Watson[21] has discussed the determination of particle size very fully in a recent paper covering also the treatment of the results and their interpretation.

Information on shape can be obtained directly in two dimensions, and in three dimensions for the surfaces of particles by the shadow-casting technique. Structure can be determined for the simpler cases by methods which will be shown in the examples later in this paper. Interior shapes and structures when shown in the electron microscope can be directly inferred in two dimensions but generally the extension to the third dimension can only be made on the basis of certain simplifying assumptions.

The interpretation of shadow-casting Formvar replicas has now been sufficiently studied[14] that it provides a dependable method for the examination of the surfaces of specimens. The interpretation of pictures of replicas is, however, more complex. One has first to deduce from the micrograph the topography of the replica and then deduce from this the contours of the original surface.

Auxiliary Techniques

A technique for the treatment of mounted specimens was introduced by Williams and Wyckoff[22] and is called shadow-casting or more briefly, shadowing. It is now widely used. The technique consists of taking the specimen mounted on a plastic film which is supported on a mesh screen and placing it, specimen upward in a vacuum chamber. (Figure 4) When the pressure within the chamber is less than one micron, a metal such as chromium is evaporated onto the specimen obliquely from a distant filament. At these low pressures the metal atoms proceed from the filament to the specimen in straight lines (since they do not collide with gas atoms). In the case of a metal such as chromium the metal atoms remain on the specimen supporting film wherever they hit. The layer of metal thus formed is thicker on those surfaces normal to the direction of approach of the metal atoms and thinner where the atoms arrive more obliquely. Moreover, shadows will be formed on the film, i.e. regions where there is no metal; the metal having been intercepted by the more elevated portions of the specimen. It is common to print the electron micrographs of such specimens by means of an intermediate photographic reversal so that the shadows shall appear dark in the final prints. If the prints are then turned so that the shadows are directed downward, an appearance of relief is evident on viewing the micrographs. There is, moreover, a noticeable increase in contrast, if the specimen is not very dense, for in this case the metal atoms scatter the electrons much more effectively. This will be evident on comparing Figures 5 and 6 which will appear with Part II. Finally, if the angle of arrival of the metal atoms at the surface of the supporting film is known, then by measuring the length of the shadows information can be obtained on the height of the specimen. It is to be noted that the information obtained by shadowing pertains only to the surface that was shadowed.

Another method which has been used to increase contrast in electron micrographs is to stain the specimen with a dense chemical. The intention in staining is to secure a specific combination with, displacement by—or absorption of—the dense chemical with certain parts of complex specimens, thereby increasing the electron scattering from those parts of the specimen. The method has been little used at present because of insufficient knowledge as to the types of stains to be used and because for those which have been employed, the effects are not predictable for different specimens.

Given is only a brief outline of some of the more important methods in electron microscopy. In the study of any given sample, the three steps—specimen preparation, electron microscopy and interpretation, should be carried out by an experienced man. Moreover, in critical cases where it is important to be sure that artifacts are not obscuring the interpretation, different methods of preparation should be used. It is to be recommended that wherever possible all three of the steps mentioned above be carried out by the same man, for only in this way can a dependable control of the examination and analysis of the results be obtained. Illustrative examples will be given later of the use of the electron microscope in research work in the hydrocarbon processing industry.

Maintenance

An electron microscope is a sufficiently complex instrument that routine testing and maintenance work may be regarded as a prerequisite to

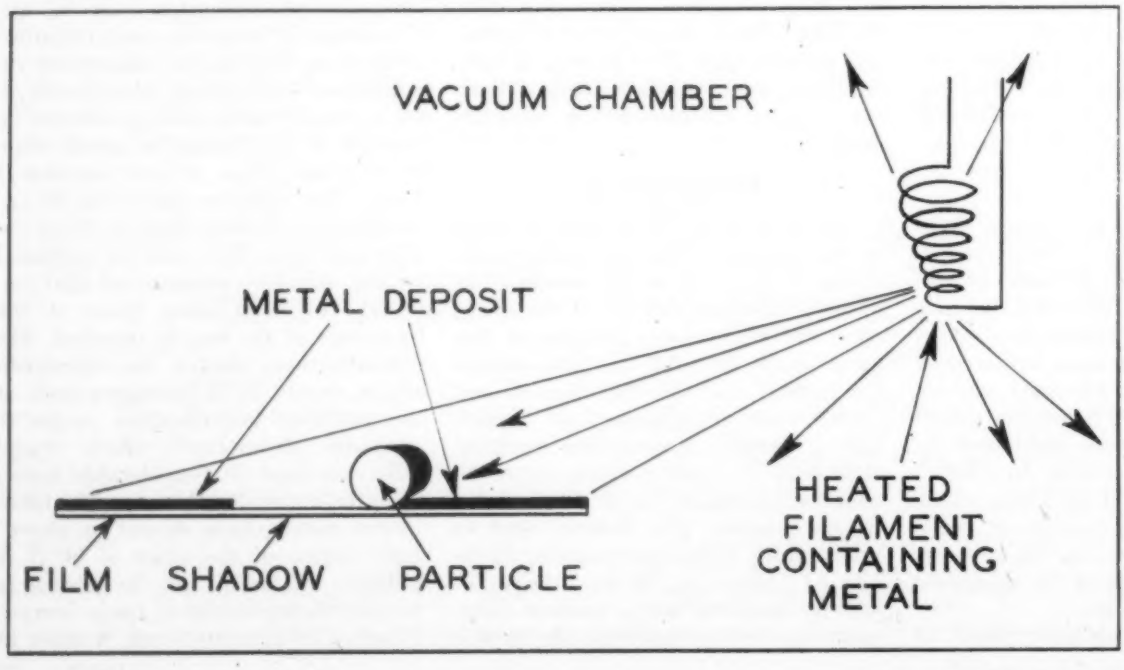


FIGURE 4

efficient operation. The Radio Corporation of America will contract to provide such a service though geographical considerations limit what can be done. In addition to such detailed and periodic attention as is provided by such a service most electron microscopists will expect to do minor maintenance work. Many competent microscopists make themselves solely responsible for the cleaning and alignment of the microscope column relying on outside service for attention to the electrical circuits, vacuum system and mechanical features. It should not be concluded from what is said in this section that the maintenance of an electron microscope presents problems of exceptional difficulty. With a little instruction and some practice many electron microscopists do all their own maintenance. A servicing contract is to be regarded, however, as a convenience.

For routine tests of resolving power, a suitable specimen is carbon, formed by collecting the smoke from burning camphor directly on a copper mesh. A thorough focal series taken at low angular aperture of the illumination should show Fresnel fringes, when the objective lens is too weak.[19] The minimum separation between fringes provides a convenient measure of the least resolvable distance.[23] It should be less than 50°A for the RCA EMU microscope* when properly handled. The best resolving power with such an instrument will be conditioned by the degree of symmetry of the objective lens and will vary from instrument to instrument.

The production of high resolution micrographs requires the simultaneous satisfaction of a number of conditions. To discover the cause of poor resolving power it usually is necessary to perform a process of elimination. To facilitate such a precedure the following representative—though by no means exhaustive—list of faults is given.

Image shifts. These are commonly due to dirt, and are recognizable as a change of image position with intensity of illumination. It may also appear as a slow movement and rapid snap-back at constant intensity. The cleaning of the column is considered below.

Other causes may be inherent in the specimen, supporting film, or mesh for which reason carbon on a heavy copper mesh is recommended as a test specimen.

Image instabilities may arise from instabilities in the lens supply circuits. By throwing the column out of alignment it is possible to make the image movements due to changes in accelerating voltage, objective current, and projector current, occur in different directions and hence, trace the source of trouble.

Vibration, if due to the forepump, can be checked by turning this pump off during an exposure. This can be done for 30 seconds without harm to the vacuum.

Stray magnetic fields produce a shift in the final image that is independent of the specimen to objective lens distance. They may be due to nearby transformers, heavy duty wiring, rotating machinery, or even the movement of large ferromagnetic bodies such as elevators. A fuller description of the precautions to be taken, if high resolutions are required, has been given by Hillier and Ramberg.[19]

Internal Cleanliness Important

The internal cleanliness of the microscope column is important since dirt, on the lenses for example, will charge up from the electron beam and deflect the electrons proceeding to the final image. This deflection will seldom be completely steady. A test of the cleanliness of the column can be made by viewing the image of a heavy mesh at 20,000X on the final screen while the intensity is varied through its maximum value. The image should shift through less than one-eighth inch. The effect of a given amount of dirt is greater as it is nearer to the beam, as the current density on it is greater, and approximately as the magnification from the dirt to the final screen is greater. The following regions, therefore, require special attention: the electrodes (and glass) of the electron gun, the condenser aperture, the specimen cartridge, the objective lens surfaces, the objective diaphragm (for high resolution it is better not to use one) the intermediate viewing screen (too much phosphor has the same effect as dirt), and the projector polepieces; of these, the surfaces near the specimen and the objective lens are the most critical.

The dirt commonly encountered may be fibrous, silicous, contamination[20] deposited wherever surfaces are bombarded by the electron beam, or grease and hydrocarbons from gaskets or fingerprints. The nature of the dirt and its situation suggests the best method for its removal. For critical and delicate surfaces such as those of the lenses polishing with a paste made from a suitable polishing powder is the best method of removing contamination. Toothpicks and lint-free lens tissue will be found invaluable in this work. The lens surfaces should be polished *very carefully* until they shine. It must be emphasized that such surfaces have been machined to a high precision and that the polishing must be done by rotation so that their axial symmetry is not destroyed. All traces of polishing powder should be removed with lens tissue and no dust should be visible when the finished lens is examined with a 10X eye lens. Less critical surfaces such as the insides of the specimen cartridge, and the filament shield can be cleaned with fine steel wool, removing the fragments of the steel wool with a bar magnet before reassembly of the parts. Contamination can be removed from platinum diaphragms by heating to red heat in a vacuum for a minute or two. Cleaning the interior of the column with organic solvents is *not* recommended since they will not remove contamination, and may indeed contribute to it when the microscope is again in operation. They serve chiefly to redistribute grease throughout the system. It is highly desirable that an electron microscope laboratory be air-conditioned but in any case the cleaning should be organized so that critical surfaces are exposed to airborne dust for the minimum time.

(End of Part I. Part II will appear next month).

* The guaranteed resolving power is better than 100 A.U.

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* Four comprehensive biographies.

Industrial

REFINERY

***FIVE BASIC** principles of industrial engineering were presented in the July, 1947, "Petroleum Refiner" and briefly outlined in their application to refinery maintenance. The five principles: organization, cooperation, planning, standardization, and review and improvement are considered to be fundamental for the general improvement of any industrial unit regardless of type. It has been pointed out, however, that the means of application or tools for carrying out these principles vary considerably with different types of industry. In another article on the same subject (Petroleum Refiner, June, 1948) covering details of organizational analysis and procedure and an instance of successful organization, the important steps were emphasized which were considered primary and basic to the creation of successful refinery mechanical department organization. The organization, once established with flexibility for progress, and with each member knowing his duties, responsibilities, opportunities, and relationship with others, is well on its way toward the cooperative spirit desired by all.*

The intention of this present article is to emphasize the importance of providing basic tools for the analysis and investigation of all plant procedures. A "job order" system with resultant cost segregation and accumulation is offered as a basis for improvement in plant routines.

THE development of a spirit of cooperation within a plant will be passed over lightly here but by no means because it is considered unimportant. To the contrary, cooperation is of utmost necessity for a smooth running organization, nullifying the results of successful instigation of the other principles should it be lacking. The brevity of the discussion on this subject is because such a study should be, and has been made by those who have devoted their careers to the art of human relations. In passing however, there are two thoughts which are fundamental in establishing cooperation within a group: 1) The supervisory and technical groups should be encompassed by management so that each feels he is a part of management and understands the problems and difficulties of the others; and 2) all employes should be treated with respect and fairness as individuals and not as numbers or "hands." Clear thinking, understanding, and imagination will dictate the methods of attaining these fundamentals.

This discussion again will be confined to the refinery mechanical department with details of successful planning programs and procedures and results obtained. Where specific methods and procedures are mentioned here, they are those used by the mechanical department whose organization was outlined in the June article. This organization consisted of 500 to 600 mechanical department employes in a typical and relatively new refinery. This company's planning program was of such effectiveness that it was indeed rare that any installation or major revamping or maintenance job was started without an estimated cost, drawings or sketches, a schedule, and materials available. It is inevitable that work so planned will be more economical, less troublesome in operation, and more efficiently laid out than those projects set upon with little or incomplete planning.

In this subject plant, important, emergency, and minor maintenance work is done by order of the operators. Advisable and desirable maintenance or changes of a larger nature require study and approval by the unit operating supervisor. Within certain cost limits, revamping and major maintenance requires the approval of local management while those above the set limit are submitted to the home office for approval.

Budget Aid in Planning

In an annual maintenance budget revised at six-month intervals, all known projects requiring home office approval are roughly estimated and submitted. This gives management two things: 1) a reasonable estimate of the amount of money to assign to plant maintenance; and 2) an opportunity to fit the plant planning into the overall company picture, thus possibly eliminating some projects as unnecessary because of other plans. With the approved budget in hand, the operating supervisor, with the aid of technologists, submits his ideas in detail to the engineers who make detailed estimates, cost summaries and economic studies for submittal to the home office. If approval is obtained, the drafting division makes drawings as required, listing the materials for issue by the stores department. This department sets aside all material on hand for the job and procures the remainder from outside. In the meantime the operating department repre-

JOB ORDER NO. _____

DEPT. ACCT. NO. DATE

DESCRIPTION OF WORK:

CLOCK NO.	TIME START	TIME FINISH	TOTAL TIME	RATE	CHARGE	ISSUED TO:
						Boiler
						Carpenter
						Electric
						Instrument
						Labor
						Mason
						Machine
						Paint
						Pipe
						Rigger
						Tin
						Weld
						Garage
						Insulating

Approved: Mech. Oper. Ordered By

FIGURE 1

Job order provides the original work request, authorization for material procurement, labor scheduling, cost accumulation, and the basis for economic study and review. Above form is provided by one firm in quadricolored pads for those authorized to issue such orders.

Engineering In MAINTENANCE PLANNING

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sentative has approved the drawings and issued an order to the maintenance division specifying when the work may be started. The stores department keeps the maintenance division informed on the progress of material procurement. When all is in readiness, the zone mechanical supervisor schedules the work to begin and follows it through to completion.

In a like manner, the capital expenditure budget is prepared, approved, and followed through, although in this budget it is necessary to indicate as nearly as possible the work which can be handled by the plant forces. This permits the home office to anticipate and plan for outside contracts on desirable projects. It is easy to see, that without these two carefully estimated budgets plus a sound estimate of routine maintenance, how a plant can become confused, jumping from one project to another, leaving some incomplete because of the press of more important work, and in general handling the job in a manner which would put a contractor in the hands of bankruptcy in short order.

Job Order Is Basis of Planning

The foundation of all work planning in this particular plant is the job order system which provides the original work request, authorization for material procurement, labor scheduling, cost accumulation, and the basis for economic study and review. The job order shown in Figure 1 is printed in quadricolored pads and distributed to all persons authorized to issue these orders. In some plants, all orders are handled by telephone and a central clerk; however, there is believed to be some merit in requesting the originator to describe his own job. One company has provided an 8½ x 11 job order form with crosshatched space for illustrating sketches.

The subject company's job order system operates in the following manner:

1. The operating foreman writes a job order in quadruplicate giving a complete description of work to be done.
   a) One copy is filed at the unit office.
2. Three copies are sent to the field clerk at the mechanical office.
   a) The copies are numbered and one is filed in a permanent numerical file and one is filed in an "open" file by units.
   b) The third copy is given to the zone supervisor.
3. The zone supervisor reviews the job if necessary and checks the various crafts required.
   a) As the master mechanic's representative, he approves the jobs which are considered routine or duly authorized, and questions only those which may require further checking, drawings or sketches, and engineering layout.
   b) For those orders requiring other than stock materials, he issues material requisitions against the job number.
   c) The material clerk informs the zone supervisor when materials are received.
4. When all materials are on hand and operating department approvals obtained, the job is scheduled for commencement.
   a) The scheduling procedure will be discussed further in this article.
5. The field clerk issues two copies of each planned job order to the craft foreman.
6. The field foreman and lead men receive a copy of their orders for the day.
   a) The craftsmen's time, names, clock numbers and rates are recorded on each job order slip and returned to the field clerk at the end of each day.
7. The clerks complete the time and cost extensions and send to the accounting department.
   a) Tabulating cards are punched with all pertinent information.
   b) Tabulating cards are also punched for all material tickets charged against each order.
8. The zone supervisor returns his copy of the order when certain of completion.
9. The clerk then closes the job by sending in a final cost accumulation.
10. This information is available in almost any form at any time for use as found beneficial.
    a) Regular monthly reports are widely distributed.

The above procedure is but a stage in the development of a job order system and obviously subject to numerous improvements. In another developing a job order system, tabulating cards are used as job tickets by the craftsmen and material tickets in the storehouse and no doubt will work out satisfactorily.

Daily Scheduling

Casually mentioned in Item 4, above, is the scheduling of the jobs from day to day, which in itself is an art of coordination, skill, knowledge and considerable experience. At the plant under discussion, the actual scheduling of a day's work for 400 to 500 men and automotive equipment consumes a mere half hour before lunch of the previous day. During the morning, the five zone supervisors

DAILY PLANNING SHEET

ZONE _____ DATE _____

| Job No. | MEN AND HOURS REQUIRED | | |

work being handled as it is discovered. Anticipated equipment and line replacements are prepared well in advance of the shut-down and job orders are written to cover all the major items of the turn-around. Unless unusual conditions are discovered, down time is kept to a minimum.

Work in progress is actively supervised by working lead men of each craft, and by field foremen. The zone supervisors also watch the job progress from the standpoint of proper installation and for the purpose of planning the next day's work. Another plant has instigated the procedure of setting up a certain craft field foreman as a "job supervisor" on any job requiring careful coordination between the crafts. There are of course other job supervision systems, some more and some less effective.

Record Analysis in Planning

Study and analysis of sound maintenance records will result in a volume of valuable information for use in many ways. One refiner plotted expected routine maintenance man hours by weeks along with a curve of man hours on the payroll to give a man-hour difference available for construction or desirable changes. This was prepared monthly, for three months in advance. Much can be learned from a composite picture of maintenance backlog and maintenance payroll. Is the plant overmanned, undermanned, in proper craft balance, or inefficiently supervised? Only reliable maintenance records can provide a basis for competent study.

The plant under study, in addition to accumulating and widely distributing maintenance labor and material costs by jobs, maintains record cards on all pumping, driving, heat exchange, and pressure vessel equipment. Other plants have gone further to include tanks, instruments, and even control valves. A sample record card for pumping equipment is shown in Figure 4. It may be noted that this card is marked at the top for a 52-week tickler file system for use with any type of preventive maintenance program desired. This plant also tabulates costs weekly against all construction jobs primarily to keep management informed on the progress, and any expected overruns. This also gives the estimators current information on costs and builds their experience for further estimating.

It has been the intention of this discussion to emphasize the importance of providing the basic tools for the analysis and investigation of all plant procedures. The job order system and resultant cost segregation and accumulation forms the basis for most improvement. As shown above in a typical refinery, the job order system is the foundation of a planning program which unquestionably results in economies never attained by those plants lacking similar planning.

Improvements Into Dollars

In the review and improvement of maintenance practices, the engineer must transform suggested improvements into dollars and cents, then compare with present costs to convince top management of betterment. If present costs are unavailable, the engineers and management are both dealing with vague and meaningless guesses. Planning should be as much a part of manufacturing as it is of production, transportation, marketing, research, and financing.

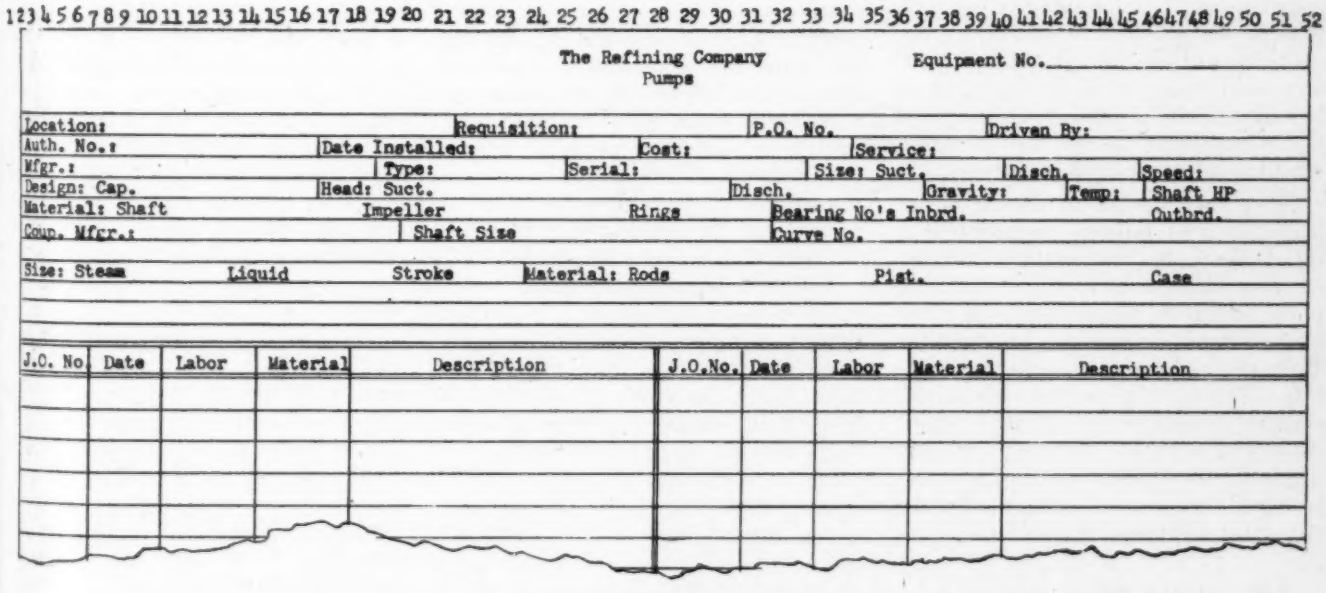

FIGURE 4

Sample Record Card for Pumping Equipment. (Note markings across top for a 52-week tickler file system, particularly effective in any type of preventive maintenance system which may be in operation.)

* * *

The Analytical Chemist And Corrosion Studies

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A GOOD example of applied analytical chemistry may be had in the study of corrosion problems. The principles illustrated in this example are equally applicable to other trouble-shooting jobs in which the analytical chemist may be consulted.

In the study of refinery corrosion problems, it is always necessary to obtain different sorts of analytical chemical information. Corrosion products from the scene of a failure must be subjected to analysis; plant streams involved are tested for suspect material; laboratory scale duplication of corrosive conditions is established for further study. Although this information is of extremely varied character, requiring skill and judgment for tests to be made and type of laboratory duplication to be set up, to obtain it does not require any more background of ability and understanding on the part of the analytical chemist than he would need for other types of problems.

Since corrosion occurrence is an inherent part of refinery operation it is self evident that the analytical chemist must become familiar enough with plant operation to produce and interpret reliable corrosion information. He must be given the opportunity to infuse himself with a thorough knowledge of plant operations, plant inspections, and something of chemical engineering techniques. Strict confinement to the laboratory, as is most often his case, and emphasis on analytical work detailed soley in standardized analytical procedures, will not permit the chemist to become familiar with the broad and particular aspects of refinery and gasoline plant operations and problems.

"Proper Balance and Place"

A very successful approach to such refinery problems is obtained when analytical chemistry is given proper balance and place in "trouble shooting" investigations. This is almost entirely due to a broadened conception of the function of the analytical chemist in a refinery.

Under this conception the chemist, while assigned a certain amount of routine analysis, has been given more important responsibilities. Besides routine work, the chemist also is assigned a particular sphere of refinery operations as his special responsibility when analytical and other chemical operating problems arise during the refinery operations. Separate assignments are water treating, boiler plant, chemical treating, and refinery corrosion.

The chemist is encouraged to understand various operating units such as thermal cracking, thermofor catalytic cracking, alkylation, and polymerization. He is expected to familiarize himself thoroughly with these operations and units and to hold himself ready and available should problems arise in their operation that might require chemical investigation and interpretation in their analysis. He is to become acquainted with the engineer responsible for operations and units concerned and learn something of engineering and operating requirements. He is free in exchange with chemical information of aid to the engineer. Both engineer and chemist together are responsible to management for solving problems essential to continuing successful operations.

The advantages of freedom of movement oustide the laboratory and knowledge of plant operation are enormous to the chemist when a problem is encountered. He is informed of the trouble immediately and very soon after is personally on the scene. He has the opportunity to talk with operators and learn of unusual conditions before failure. He is certain to obtain any samples for analysis by his own hand and often, if peculiarities are noted, taking three or four for separate analysis.

Cultivate Friendships

From the knowledge of products processed, impurities likely to be present, and metals of equipment involved, the chemist can economically later on limit his methods and scope of analysis. It is especially advisable to cultivate the friendship of operators and helpers, who may divulge practices not ordinarily connected with unit operation. Temperatures may have fluctuated, raw water may have been cut into treated and forgotten, unit upset may have occurred and not be registered by instruments. After questioning all around, with the engineer, operator, and helpers, the chemist may have some clue as to the cause of trouble. The analysis then is made, and pointed in the direction indicated by deductions. The clues will ordinarily be substantiated; and results often may call for more analysis of feed streams and draw-off streams for final proof of the presence and quantity of suspect material. Complete information is essential, for it is the only basis for intelligent attack on place and type of control.

After the analysis has been obtained, it is important to go over the tentative findings with the engineer in charge of whatever operation was under investigation. His opinions will be valuable in assessing the significance and value of whatever chemical recommendation the chemist may have in mind. The engineer may suggest what further data might be necessary for engineering calculation based upon the report.

Too often satisfactory work is accomplished in the laboratory, but is so

■ CONTINUED ON PAGE 96

THE ANALYTICAL chemist has much to offer refinery management, engineers, and other users of chemical information in the operating phase of refining and natural gasoline manufacture. It is unfortunate but true that the analytical chemist's capabilities and potentialities often are not recognized by others "outside" his field when his work bears on the solution of plant problems. The chemist is usually connected with merely the analytical chemistry portion of the plant problem at hand, and hence is in no position to bring his knowledge to bear on factors which may otherwise escape consideration. Due to non-specialized training on the part of others, the analysis called for may not be sufficiently all-inclusive, and the analyst actually may be hindered in his work, albeit unintentionally. It is certain that acquaintance with the analytical chemist and his work will do much to further maximum use of chemical information and increase the overall efficiency and productivity of refinery technical groups.

STEAM DEMAND OF Direct Acting Reciprocating Pumps

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***BECAUSE DIRECT** acting reciprocating steam pumps are widely used in process plants it is often desired to calculate their operating efficiency and steam consumption. Several methods for approximating these figures have been used by many engineers with varying satisfaction. Answers have generally been either inaccurate, or tedious in calculation. A procedure has been developed for calculating these data for pumps in service. A study was made on the basis of available reference material and the present system is the result. Earlier methods in many cases gave base rates of pump steam consumption which exceeded the actual rates. It is believed that the discrepancies resulted from calculations based on boiler pressure instead of actual pressure at the pump steam chest. To avoid the errors inherent in the commonly used empirical methods, this present procedure has been worked up from basic reciprocating pump theory.*

DEFINITIONS

A DIRECT acting steam pump is a pump without connecting rods, crankshaft, or fly wheel where the steam pistons and liquid pistons or plungers are directly connected by piston rods or by side rods.

Unless otherwise stated, the symbols shown below as used in this memorandum are defined as follows:

P_t = Steam cylinder pressure in psia. (terminal pressure)
P_1 = Differential pressure—steam end psi.
P_2 = Differential pressure—liquid end psi.
P_b = Exhaust pressure—steam end psia.
V_t = Volume of steam in cubic feet per pound at P_t.
V_b = Volume of steam in cubic feet per pound at P_b.
A = Total end areas of one piston on liquid end in square inches.
A_s = One end area of one piston on steam end in square inches.
N = Rpm. (actual).
N_t = Theoretical rpm.
L_a = Total actual length of strokes of all pistons in inches (measured).
L_t = Total designed or theoretical length of strokes of all pistons in inches.
L_e = Total equivalent length of strokes of all pistons on steam end in inches.
D_1 = Diameter of steam cylinder in inches.
D_2 = Diameter of liquid cylinder in inches.
E_m = Mechanical efficiency (includes slip)
E_v = Volumetric efficiency.
E_s = Steam efficiency.
S_1 = Actual pounds steam demand per hour.
S_2 = Pounds steam required to pump same quantity as S_1 above, if operation was at design conditions.
C = 0.06944 (A conversion factor obtained from $\frac{60 \text{ min./hr.} \times 2 \text{ strokes/rpm}}{1728 \text{ cu. in./cu. ft.}}$
S_3 = Pounds steam required to pump the metered quantity if pump were operated at design stroke with normal losses and slip.

THE actual procedure finally worked out for the estimation of steam consumption by direct acting steam pumps is fairly straight forward. A nomograph has been developed to simplify the work of calculation and it is believed that the method will be found quite practical for general application to process plant pumping problems.

Estimating Steam Demand

1) Pumping rate (from plunger displacement)

$$\text{Bbls./hr.} = \frac{A \times L_a \times N}{161.7}$$

This quantity is the amount that would be pumped providing there were no slip. It is the actual displacement of the liquid end.

2) Differential pressure steam end:

$$P_1 = \frac{D_2^2 \times P_2}{D_1^2 \times E_m}$$

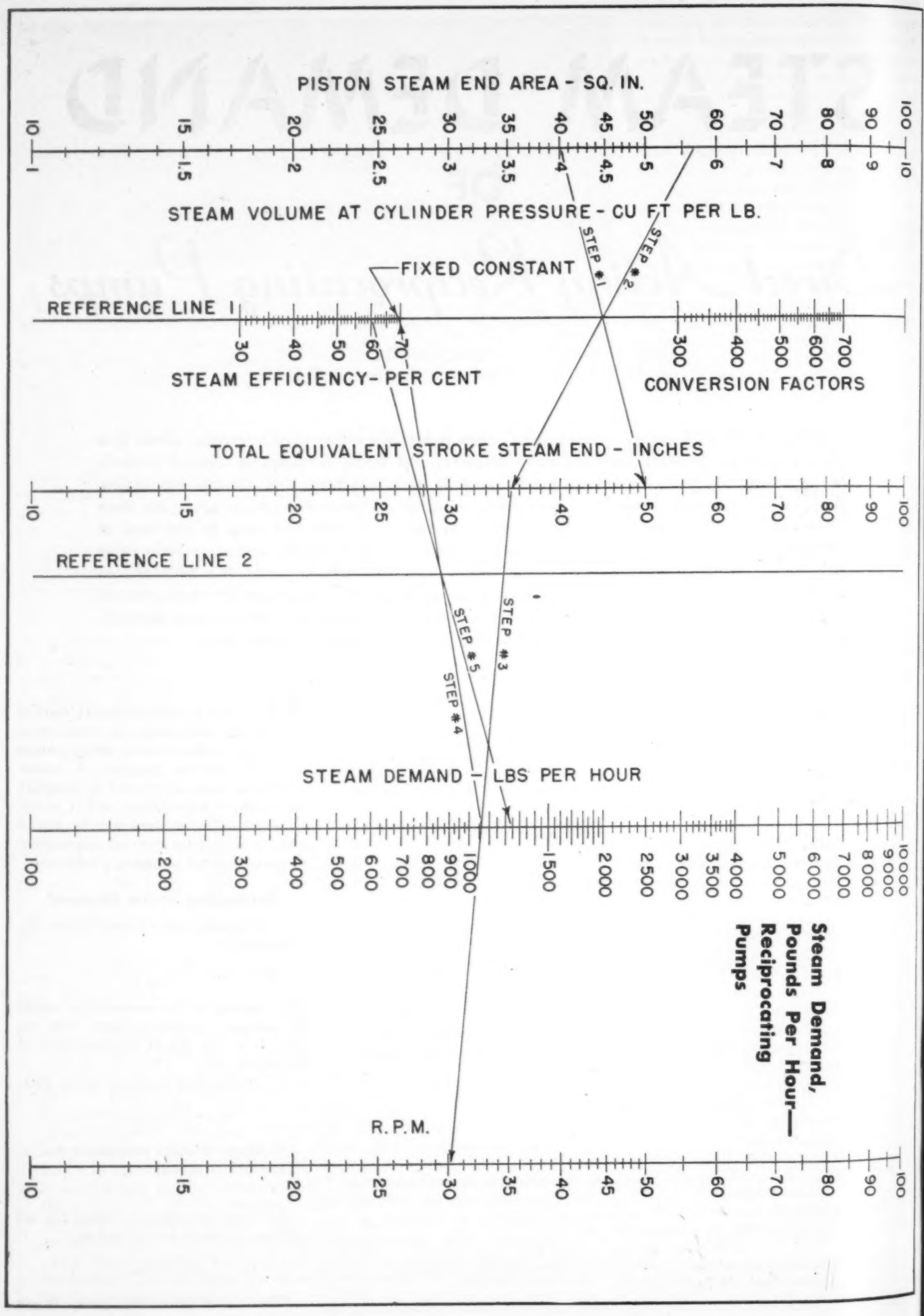
3) Steam cylinder pressure in p.s.i.a. (Terminal Pressure)

$$P_t = P_1 + P_b$$

4) Total equivalent strokes for all pistons on steam end in inches:

$$L_e = L_t - \left((L_t - L_a) \times \frac{V_t}{V_b} \right)$$

Often, a reciprocating pump is not


PISTON STEAM END AREA - SQ. IN.
10 15 20 25 30 35 40 45 50 60 70 80 90 100
1 1.5 2 2.5 3 3.5 4 4.5 5 6 7 8 9 10
STEAM VOLUME AT CYLINDER PRESSURE - CU FT PER LB.
STEP #1
STEP #2
FIXED CONSTANT
REFERENCE LINE 1
30 40 50 60 70
STEAM EFFICIENCY - PER CENT
300 400 500 600 700
CONVERSION FACTORS
TOTAL EQUIVALENT STROKE STEAM END - INCHES
10 15 20 25 30 40 50 60 70 80 90 100
REFERENCE LINE 2
STEP #5
STEP #3
STEP #4
STEAM DEMAND - LBS PER HOUR
100 200 300 400 500 600 700 800 900 1000 1500 2000 2500 3000 3500 4000 5000 6000 7000 8000 9000 10000
Steam Demand, Pounds Per Hour— Reciprocating Pumps
R.P.M.
10 15 20 25 30 35 40 45 50 60 70 80 90 100

operated at the design length of stroke. When this condition occurs, an excess quantity of steam is required in the steam cylinder when the pump has completed exhaust to bring the exhaust pressure in the cylinder up to operating pressure. This condition is caused by the shortened stroke, which results in a space $L_t - L_s$ to which high pressure steam must be added to bring the pressure up to terminal pressure before the power stroke can begin. The equivalent space to which steam must be added, however, is proportional to the ratio of the volume of the steam at P_t and the volume of the steam at P_b.

5) Volumetric efficiency:

$$\times 100\% \quad E_v = \frac{\text{Quantity pumped bbls./hr. (measured)}}{\text{Plunger displacement bbls./hr.}}$$

$$\text{Slip} = 100 - E_v$$

6) Actual pounds steam demand per hour: (Look up total heat in steam at line pressure and use this value with actual cylinder pressure, i.e. P_t, to get actual volume 1 pound of steam will occupy according to the steam tables, i.e. V_t.)

$$S_1 = \frac{A_s \times L_s \times N \times 0.06944}{V_t \times E_s}$$

7) Theoretical rpm: (No slip or short stroke).

$$N_t = \frac{\text{Measured bbls./hr.} \times 161.7}{A \times L_t}$$

8) Base rate for theoretical operating conditions: (Use E_s at design stroke.)

$$S_2 = \frac{A_s \times L_t \times N_t \times 0.06944}{V_t \times E_s}$$

9) Steam demand for pump operating at design stroke with slip.

$$S_3 = \frac{S_2}{E_v}$$

10) Steam loss caused by slip:

$$\text{Loss} = S_3 - S_2 \text{ (lbs./hr.)}$$

11) Steam loss caused by short stroke:

$$\text{Loss} = S_1 - S_2 \text{ (lbs./hr.)}$$

12) Steam loss caused by short stroke and slip:

$$\text{Loss} = S_1 - S_2 \text{ (lbs./hr.)}$$

13) It should be borne in mind that the steam demand calculated from the above formulae actually allows for normal slip. This slip is included in the mechanical efficiency and increases the differential pressure P_1, above the actual, which in turn reduces the volume and increases the steam demand.

Nomograph

A nomograph was developed to solve for S_1 and S_2 when all factors in the formula are known. For the example shown on nomograph: $A_s = 40$ sq. in., $L_t = 50$ in., $V_t = 5.7$ cu. ft./lb., $N_t = 30$ rpm, $E_s = 60\%$. The steam demand of 1240 lbs./hr., was obtained as follows:

Step 1: Place a straight edge on the graph so that it intersects the area scale at 40 and the stroke scale at 50, respectively. The intersection of straight edge with reference line 1 is first pivot point.

Step 2: Place the straight edge so that it intersects reference line 1 at the first pivot point and the volume scale at 5.7, respectively. The intersection of straight edge with stroke scale is second pivot point.

Step 3: Place the straight edge so that it intersects the stroke scale at second pivot point and the rpm scale at 30 respectively. Intersection of straight edge with steam demand scale is third pivot point.

Step 4: Place the straight edge so that it intersects the steam demand scale at the third pivot point and the steam efficiency scale at the fixed constant point (C) of 0.06944 respectively. This constant is not related to the steam efficiency scale, but is placed there for convenience only to reduce size of nomograph. The intersection of straight edge with reference line 2 is fourth pivot point.

Step 5: Place the straight edge so that it intersects the reference line 2 at the fourth pivot point and the steam efficiency scale at 60, respectively. The intersection of straight edge with steam demand is answer in pounds per hour.

On attached nomograph will be noted a scale of conversion factors. This scale is used to keep readings from extending beyond the nomograph scale and to obtain greater accuracy. For example, if in Step 5 the answer (steam demand in pounds per hour) falls on top portion of scale at some value above 4000 pounds per hour, it is difficult to obtain an accurate answer; or if the answer exceeds 10,000 pounds per hour it falls off the scale. For example, assume the following conditions: $A_s = 40$ sq. in., $L_t = 50$ in., $V_t = 3.0$ cu. ft./lb., $N_t = 80$ rpm, $E_s = 30$ percent.

Step 1: Place a straight edge on the graph so that it intersects the area scale at 40 and the stroke scale at 50, respectively. The intersection of straight edge with reference line 1 is first pivot point.

Step 2: Place the straight edge so that it intersects reference line 1 at first pivot point and the volume scale at 3.0 respectively. The intersection of straight edge with stroke scale is second pivot point.

Step 3: Place the straight edge so that it intersects the stroke scale at second pivot point and rpm scale at 80, respectively. Intersection of straight edge with steam demand scale is third pivot point.

Step 4: Place the straight edge so that it intersects the steam demand scale at third pivot point and the steam efficiency scale at fixed constant point of 0.06944, respectively. Intersection of straight edge with reference line 2 is fourth pivot point.

Step 5: Place the straight edge so that it intersects reference line 2 at fourth pivot point and steam efficiency scale at 30, respectively. Intersection of straight edge with steam demand scale is answer; however, the steam demand is greater than 10,000 lbs./hr. and falls off chart. To obtain a reading on the graph, the conversion factor scale must be used as follows: In Step 5, the straight edge is placed so that it intersects reference line 2 at fourth pivot point and conversion factor scale at E_s multiplied by 10, which in the example above would equal to 300 ($E_s = 30 \times 10 = 300$). Intersection of straight edge with steam demand scale is a factor (1275), on lower portion of graph, which, when multiplied by 10, gives answer of 12,750 lbs./hr.

Efficiencies of Simplex Cylinder Reciprocating Steam Pumps
(Taken from Gulf Oil Corporation Standard P-1007)

Stroke	Mech. Eff.	Steam Eff.
4	55.0	37.5
5	60.0	38.75
6	65.0	40.0
7	67.5	41.25
8	70.0	42.5
9	72.0	43.75
10	74.0	45.0
11	75.75	46.25
12	77.5	47.5
13	78.3	48.3
14	79.2	49.2
15	80.0	50.0
16	80.8	50.8
17	81.7	51.7
18	82.5	52.5
19	82.9	52.9
20	83.3	53.3
21	83.8	53.8
22	84.2	54.2
23	84.6	54.6
24	85.0	55.0

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[1]Gulf Oil Corporation Standard P 1007.
[2]Marks Handbook, Fourth Edition, 1941.
[3]Steam Power Plant Auxiliaries and Accessories, Croft, First Edition, 1922.
[4]Steam Power Plant Engineering, Gerhardt, Fifth Edition, 1917.

* * *

Petroleum Rust Preventives

VARIOUS GRADES AVAILABLE NOW FOR PRACTICAL APPLICATION, CONDITION AND LENGTH OF SERVICE BEING THE BIG FACTORS

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RUST or corrosion of metals is a familiar phenomenon, especially in iron and steel. Metals will corrode and rust when exposed to the atmosphere, either through the action of moist air, corrosive gases such as hydrogen sulphide, chlorine, and sulphur dioxide, etc., or by coming in contact with salt solutions.

Rust causes a tremendous loss annually. This loss can be greatly reduced by use of suitable rust preventives. Paints form an ideal protective film, but cannot be applied to highly polished or friction surfaces or to parts to be assembled. Petroleum rust preventives, then, find their principal application in those cases where finished metal surfaces must be temporarily protected until final assembly into a finished mechanism will make further protection unnecessary, and in those cases where the finished surfaces are employed in outdoor or other exposed services so that continued protection is required. In this last case, the periodic renewal of the protective film is, of course, mandatory if satisfactory protection is to be achieved.

Ideal Rust Preventives

Research has shown that some rust preventives peel off during hot weather, others crack during cold weather, and still others run off without leaving the slightest trace of a covering or protective film. The ideal rust preventive should have the following cardinal points:

1) They must give perfect protection under certain specific conditions.
2) They must be easily applied.
3) They must not foam, separate or curdle.
4) They must not gum or dry.
5) They must not drip or run off in storage.
6) They must not be injurious to workers.
7) They must be readily removable, when necessary.
8) They may be used as a lubricant.

Kinds of Rust Preventives

Rust preventives now on the market not only prevent corrosion from external sources and from moisture held in the pores of the metal by hydroscopic action of the salts used in quenching operations, but to some extent will also prevent electro-chemical corrosion. Compounds that show a perfect and uniform protective film when first applied, may break down due to their surface tension or tendency to draw together into infinitesimal globules, leaving some small areas of the metal unprotected.

Nature of Rust Preventives or Slushing Compounds

Nearly all petroleum rust preventives (temporary coatings) can be removed fairly easily from the finished surfaces. They range from light slushing oils to the heavy grease-like compounds. Materials stored indoors and exposed only to the moisture of the atmosphere may be protected with a light film of light grade slushing oil, either by spraying or dipping. Materials of large size which cannot be protected from dust and dirt require a heavier grade of oil or a grease-like rust preventive compound which is usually not easily removed by ordinary handling or storage.

For outdoor storage, where the material is exposed to the weather, salt solutions, chemical fumes, etc., it is best to use the heaviest type rust preventive, one that will form a protective film and will not drain off for a long period of time. The heavier types of compounds are applied according to their consistency and may require heating, while the lighter grades can be sprayed, brushed or swabbed on.

Tests

Research has shown that ordinary films or petroleum oils will allow moisture and air to penetrate to the metal surfaces. To overcome this serious defect special compounds have been developed to meet the requirements of a variety of applications, and suitable specifications and test procedures have been worked out, so that reasonably satisfactory selection of rust preventives can be made. Government specifications for rust preventives cover some 12 different groups, both oils and compounds. Some of the important methods used for evaluating such materials include tests under accelerated heat and humidity conditions (humidity cabinet tests), outdoor climatic tests (exposure to sun and rain), ultra-violet ray tests (accelerated sunlight) water resistance tests, and salt solution and spray tests. Only the adhesion and protection tests of the heavier grades will be discussed in this paper.

The United States Navy specifies for the adhesion and protection tests of Grade A (heavy) rust preventive, four mechanically polished steel plates 4 inches by 6 inches by 1/8 inch which are thoroughly cleaned with benzol before application of the preventive. The material to be tested is melted and heated to 158° F. and an excess slushed over the plates.

One plate is kept in a vertical position in the laboratory for 24 hours, and then placed in an outdoor rack exposed to the weather. The plate is inclined at an angle of 45° to the vertical, facing south, and is then sprayed lightly with a 3 percent salt solution and left exposed to the weather for not less than 5 nor more than 60 days.

The other three plates are hung in a vertical position in an oven and maintained at a temperature of 45 to 50° C. (113° to 122° F.) for at least 48 hours. After cooling to room temperature, one plate is placed in the rack described above. Another treated plate is placed in a horizontal position and lightly sprayed with a 3 percent salt solution once every day for a period of 5 days. The fourth plate is placed under an intermittent shower for 3 to 4 minutes, then no water for about the same length of time. The water is run through a metal trough, the bottom of which has three or four parallel rows of small holes, 1/16 inch in diameter. The water should fall about 2 feet from the trough to the plate. This test should be continued for not less than 5 hours, the plates being held in a position about 60° to the vertical. The plate is now placed

in a horizontal position and allowed to remain with any adhering water for at least 24 hours. No rust shall be in evidence on any of the four plates.

The Grade B (medium) and Grade C (light) rust preventives are tested as for Grade A (heavy), but the temperature of the rust preventive material is only 100° F. when poured on the plates, and in addition, duplicate polished steel rods 6 inches by ¾ inch are coated for test purposes. The plates with the medium rust preventive are placed in an oven at 113° to 122° F. for 5 hours, but the light rust preventive compound is not heated in the oven. The plates are allowed to stand in a vertical position at room temperature for 24 hours and then sprayed with a 3 percent salt solution, twice a day for five days.

Army Specifications

Duplicated coated plates and rods are suspended in distilled water for 5 days changing the water each day. At the end of this time there should be no evidence of rust on any of the plates or rods. The United States Army specifies for the adhesion and protection tests of heavy rust preventive compound (Number 2-02C) that five plates of cold rolled strip steel WD1020, 2 by 3 inches shall be employed. All edges are rounded by mechanical polishing and the plates are cleaned with benzol. The plates are dipped in the heated compound, temperature not exceeding 180° F. for a period of time sufficient to insure a coating on the plate of approximately 3/64 inch in thickness. One plate is exposed to water on a rack inclined at an angle of 45° to the vertical, facing south, for a period of 30 days. The second plate is weighed, both before and after coating to the nearest milligram, and then suspended for 4 hours in an oven heated to 135° F., then cooled and reweighed. Loss in weight of more than 5 percent of the original coating is cause for rejection. The third plate is hung in an oven of 100 percent humidity at 100° F. for seven days. The fourth plate is exposed to ultra-violet ray light for five hours a day for seven days, and the fifth plate is placed alternately in the 100 percent humidity oven for 19 days, then in the ultra-violet ray light for five hours, then back in the high humidity again, etc., for seven days. The ultra-violet ray light is obtained from an automatic carbon arc. One hour of this light equals six hours of sunlight. The coated plates are held 12 inches from the arc. The temperature at the plate is not permitted to exceed 120° F. Any cracks which appear in the protective film as a result of the conditions outlined for plates, three, four and five are considered cause for rejection. Where cracks occur, the plates will show signs of rust after they have been cleaned with benzol or waste soaked in kerosine.

Specifications

For the protection of highly finished metal surfaces against corrosion for a period of approximately one year in indoor storage, the United States Army has developed a specification for light rust preventive No. 2-84B compound. This compound shall be homogenous, stable, non-corrosive, and rosin-free material of brushing consistency at 60° F. It shall have a minimum penetration of 275 (unworked). There shall be no separation of the mineral oil and other components used in this product, or separation of solid or liquid matter after heating to 200-210° F. for one hour. For volatility and other requirements, see Spec. No. 2-84B.

For services requiring a lubricating preservative, the United States Army has developed a special low-pour-point preservative lubricating oil designated No. 2-210-oil which has the following characteristics:

Viscosity, Kinematic, Centistokes at 100° F Minimum	12.0
Viscosity, Kinematic, Centistokes at -30° F maximum	3000.0
Flash Point, ° F. minimum	275
Pour Point, ° F. maximum	-70

This oil shall consist of highly refined mineral lubricating oil, containing additives necessary to fulfill the requirements specified.

For the protection of highly finished metal surfaces against corrosion for a period of approximately one year in indoor storage, the United States Army has developed a specification for medium rust preventive No. 2-121 compound. This product shall be a homogeneous, stable, non-corrosive, non-drying, non-poisonous, rosin-free material. Wide latitude in the selection of raw materials (mineral oils, waxes, additives, etc.) is allowed. The consistency of the unworked penetration of the compound shall not be less than 120 nor more than 160. It must be stable and uniform when heated to 200-210° F. for one hour.

The United States Army specification No. 2-122-oil covers a medium lubricating preservative. It consists of a highly refined mineral lubricating oil containing additives necessary to fulfill the requirements as shown in Table 1.

Table I

Viscosity, Saybolt Universal at 130° F. seconds	185 to less than 255
Pour Point, ° F. maximum	20

The United States Army specification No. 2-126-oil is for an engine preservative.

Grade 1—A light grade equivalent in viscosity to SAE 10.

FIGURE 1

Corrosion Test-Humidity Cabinet Used in Aeronautical Standard Specification No. AN-H 31.

Courtesy, Precision Scientific Co., Chicago

Grade 2—A medium grade equivalent in viscosity to SAE 30.

Additive agents, if used, shall not appreciably increase the tendency of the base oil to foam and shall remain uniformly distributed throughout the oil at all temperatures above the pour point up to 250° F.

The United States Ordnance Department tentative specification AXS-673 Revision 2-compound covers rust preservative of thin film properties, which is intended to protect metal surfaces against corrosion in either indoor or outdoor exposure and during domestic and overseas shipment. It shall be suitable for application by spraying or dipping. It can be made from a steam-refined cylinder stock, cutback with a volatile solvent. (Solvent content, maximum 60 percent). It must be applied cold (without first heating). For flow point, film thickness and low temperature adhesion, see specification AXS-673 (Rev. 2).

The United States Ordnance Department tentative specification AXS-1347-compound is for a rust preservative of special properties which when used in conjunction with prescribed packaging methods will protect anti-friction bearings against corrosion in storage and shipment. The consistency of the unworked penetration of the compound shall not be less than 200. There shall be no separation into layers of different appearance or separation when the material is heated to a temperature of 200°-210° F. for one hour. It is manufactured mainly from Pennsylvania petrolatum.

The United States Ordnance Department tentative specification AXS-1759-compound covers a rust preservative having soft film properties. Two grades are described.

Grade 1—Medium grade intended primarily for the preservation of critical surfaces in long term indoor storage.
Grade 2—Light grade intended primarily in conjunction with some type of carrier material for use on critical phosphated and parkerized surfaces in long term storage.

The mineral solvent used in the manufacture of the soft film rust preventive compound shall be non-toxic and shall conform to the distillation requirements of federal specification P-S-661.

	Grade 1	Grade 2
Flash point, ° F. minimum....	100	100
Flow point, ° F. minimum....	140	130
Film thicknes, in. maximum	0.002	0.0008

For other detailed requirements see Table 1 in specification AXS-1759.

Analysis of each case will determine which grade to use, such as length of time in storage, climatic conditions of storage, distance to be shipped, kind of wrapping, etc. Oil-proof paper or plastic sheeting should be used whenever petroleum rust preventives are used to wrap small items, such as ball and roller bearings, crankshafts, valves and so forth. Some of the early rust preventives which are still in use, were made mostly from Pennsylvania petrolatum as the main ingredient.

The light oils used commercially have a viscosity of from 85 to 250 SSU at 100° F. These straight mineral oils are used chiefly for the protection of sheet steel, but do not give complete protection as rust preventives in the presence of moisture.

Protection Against Gases

The light slushing oils, however, are compounded to give perfect protection against gases usually occurring in certain steel mills and have to meet very severe tests. Such a product can be manufactured from 95 percent SAE 50 oil, 3 percent lanoline, and 2 percent kerosine, plus a trace of paraflow and corrosion inhibitor. The finished product has a viscosity of 86-90/210° F. and a pour point of +15° F. A slushing oil, suitable for electric cables (lead covered), can be made with 3 percent micronized wax, 6 percent Spl. heavy rosin oil, 50 percent Pennsylvania petrolatum and 41 percent Mid-Continent oil of 200 SUS/100° F.

The ASTM tests for rust prevention characteristics (ASTM Designation D-665-44T) can be used to check results of various inhibitors. Rust preventive oils range in viscosity from 35 SSU at 100° F. up to the heavy grades of cylinder stocks.

The light-bodied slushing oils are used to protect small arms, internal combustion engine parts, etc. (indoor and sheltered). The heavier-grease-like types can be used for longterm inside and outdoor storage of large parts and assembled machines, depending upon their composition. To obtain a slight consistency for some of the heavy grades (indoor storage), a small amount of micronized wax, ozokerite, etc., may be added to the cylinder stocks and finished with a small amount of paratac, Vultex or Latex solution or a combination of these components. The compound shall be of such a consistency that it shall be applicable by dipping at a temperature not above 180° F. The penetration shall be 60-90 at 77° F. The melting point shall be 150° F. min.

The advantage of some of these "polar" compounded oils, especially those compounded with a small amount of degras or lanoline in the medium and heavy grades of rust preventive compounds result in increased adhesion and emulsify small amounts of moisture that may be present.

Some fatty oils used in compounding are not as stable when used over a long period of time, and are not satisfactory in regard to oxidation. Corrosion inhibitors used in certain rust preventive compounds include phosphoric acid esters, arsenic-antimony, organic compounds of chromium, bismuth, etc.

As an interesting comment in closing it might also be noted that, in addition to the non-drying petroleum rust preventives, several hard drying protective coatings are manufactured. During World War II, strippable coatings were developed. They are based on vinylite resin which can either be power-sprayed or used as a dip, to form impervious coatings. These coatings can be readily peeled from tools, dies or automotive parts that may have to be shipped overseas.

The Analytical Chemist

■ CONTINUED FROM PAGE 9

ineptly reported it never receives attention. The chemist should gather and include all relevent information he can in his written report. The report should be easily readable and show evidence of thought and care in its composition. The laboratory report should not confine itself to details of the failure. The report should serve also to bring attention to corrective measures. As many of these as possible should be outlined. This is to enable the engineer to make a choice based not only on chemical, but also on economic grounds. The most desirable chemical answer may often not be the most economical. A second or third chemical possibility may prove the only correction possible from a cost standpoint.

The result of this kind of investigation and report is a well balanced, complete chemical review of the problem under investigation. The coordination of chemical and engineering aspects of the problem are in harmony and complete. Teamwork has been introduced into the efforts of the refinery chemist and engineer. Facts and recommendations are furnished management that may be definitely translated into some concrete corrective measure, and this will result in definite improvement in refinery operation.

ACKNOWLEDGMENT

The author wishes to express his appreciation to the management of The Pure Oil Company, Chicago, for permission to publish this paper.

(Editor's Note—In an early issue the author will present working reports by a refinery analytical chemist on several corrosion problems.)

Left—Before. Scale on condenser section before cleaning with acid.
Right—After. Condenser section after scale had been dissolved by circulating a 12 to 15 percent solution of hydrochloric acid over section.

Water Scale Removal from Cooling Units

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RECENTLY at a Gulf Coast refinery, scale which had formed on atmospheric condenser sections was successfully removed by dissolving the scale with a dilute hydrochloric acid solution.

Scale on several of the condenser sections had completely coated the tubes, seriously reducing heat transfer from the vapors passing through the condensers. This condition resulted in an extremely hard and mortar-like scale which could not be conveniently removed by the usual mechanical methods of cleaning. Chipping the scale by hand required considerable time and labor and resulted in damaging a large percent of the condenser tubes.

Laboratory tests on samples of the scale indicated that the scale consisted principally of calcium carbonate with salts of magnesium and sodium also present. After testing the scale samples in various cleaning solutions, it was found that a 12 to 15 percent solution of commercial hydrochloric acid would effectively dissolve the deposited scale.

The diluted acid solution was circulated by a small centrifugal pump over the sections upon which the scale had formed. Distribution over the length of the sections was accomplished by a perforated header at a rate of 10 to 12 gallons a minute. Acid dripping from the sections was recovered in a tray located under the section and recirculated over the scale.

As the reaction between the hydrochloric acid and the scale converted the scale to a soluble salt, the percentage of available chlorine in the circulating solution was reduced constantly and fresh makeup acid was added to the solution to maintain an optimum concentration of available chlorine.

Measuring the Chlorine

To determine the amount of available chlorine in the solution, an accurately measured volume of the acid solution was neutralized with a standardized solution of sodium hydroxide. For convenience in field testing, the normality of the caustic solution is prepared so that one cubic centimeter of the solution is equivalent to one percent of available chlorine. By experience it has been found that when the acid solution is depleted to a concentration below 6 or 8 percent available chlorine the circulation time is materially increased and it is not practical to operate with such a dilute solution.

Facilities for circulating the acid were installed and operated at this particular refinery without removing the condenser section from the cooling tower. Occasionally during the operation, the circulation of the acid solution was stopped and the section washed down with water. Considerable scale loosened by the reaction of the acid was removed by water washing.

When the scale had been removed from the condenser sections, the sections were thoroughly washed with water to remove the acid. While the time required for the removal of the scale varied with the quantity of scale, approximately eight hours of acid circulation was required to clean each condenser at this particular plant.

Metal inhibitors to protect the condensers and the equipment needed for the cleaning operation were used in the acid solution.

Bleeding Tendency of PETROLATUM

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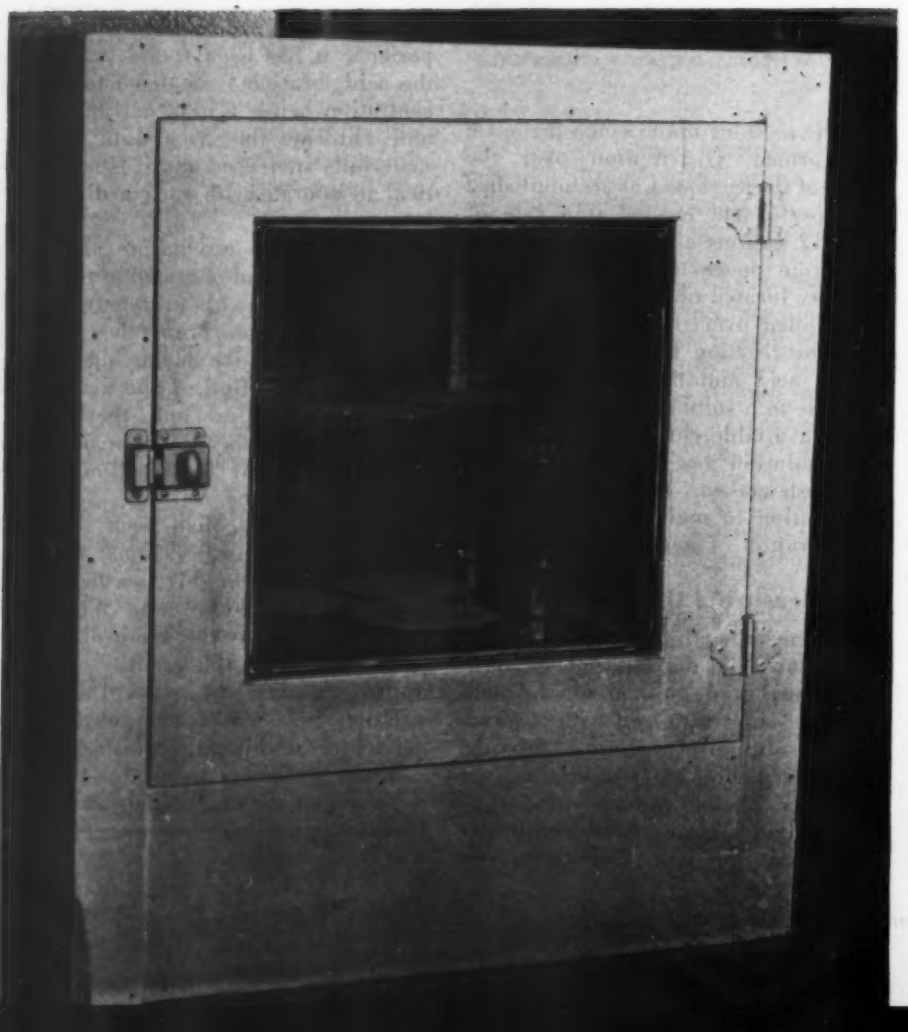
THERE DOES not exist a sufficient number of tests to evaluate petrolatums adequately from the viewpoint of quality. Tests measuring such physical qualities as melting point, consistency (or hardness), viscosity, or color, are well established. In order to define the quality of a petrolatum, however, tests for physical properties are not sufficient. For this purpose functional tests are more valuable. One of the important functional properties of a petrolatum is its tendency to "bleed" or "stain." To evaluate this property the authors have devised the test described. The procedure is simple and reproducible, and has been in successful use for several years in the plant control of the quality of petrolatums.

PETROLATUM is defined by the U. S. Pharmacopoeia as a "purified mixture of semi-solid hydrocarbons, chiefly of the methane series of the general formula $C_n H_{2n} + 2$. [It is a] yellowish to light amber or white, semi-solid unctuous mass; practically odorless and tasteless." Gurwitsch and Moore[1] state that "[petrolatums] are pasty mixtures of solid paraffin hydrocarbons and mineral oils . . . [They] are obtained from paraffin wax-containing petroleum crude oils, and are residues concentrated to a certain consistency and correspondingly purified."

Both definitions are vague. However, many products are not readily defined in words: such products must actually be defined in terms of their properties, and specifications are set up for this reason. These specifications serve two broad purposes: 1) They permit the producer to offer his customers a standardized product. 2) They permit the customer to check on the quality of the product and to compare it with that of other producers.

FIGURE 1
Thermostatically Controlled Oven Used in Determining Bleeding Numbers of Petrolatum and Similar Products.



New Test Needed

Unfortunately, there does not exist a sufficient number of tests to evaluate petrolatums adequately from the viewpoint of quality. On the other hand, tests measuring such physical properties as melting point, consistency (or hardness), viscosity, color, etc., are well established. But in order to define the quality of a petrolatum, tests for physical properties are not sufficient. For this purpose functional tests are more valuable.

One of the important functional properties of petrolatum is its tendency to "bleed" or "stain." To exemplify this property, when a sample of petrolatum in the solid state is spread on a piece of paper it will be noticed that an oily stain appears on the reverse side. Shortly after, an oily ring surrounds the petrolatum. However, not all petrolatums have the same tendency to stain. Since excessive staining is undesirable, a test which could measure this property quantitatively would not only be useful for manufacturing control but would help the user to evaluate the various petrolatums.

There is no reference to such a quantitative test for petrolatums in

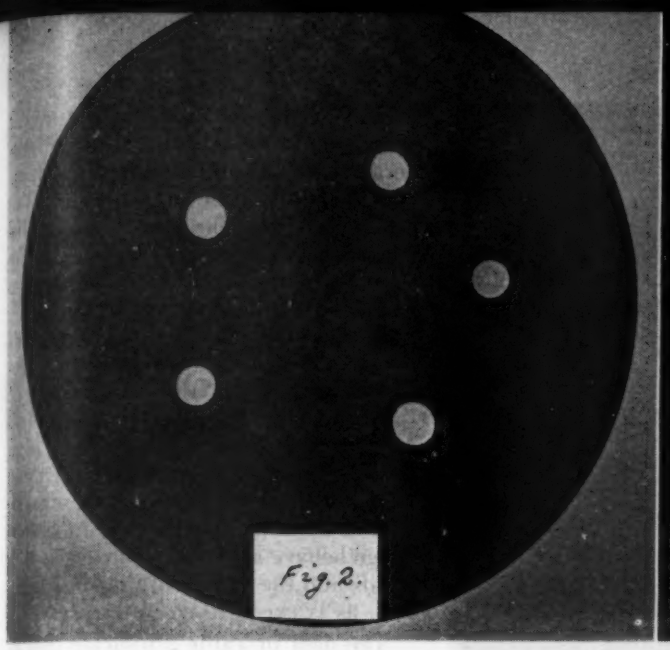


FIGURE 2—Drops of Petrolatum on Filter Paper to Be Placed in Oven. (Each drop should be about 6-8 mm. diameter.)

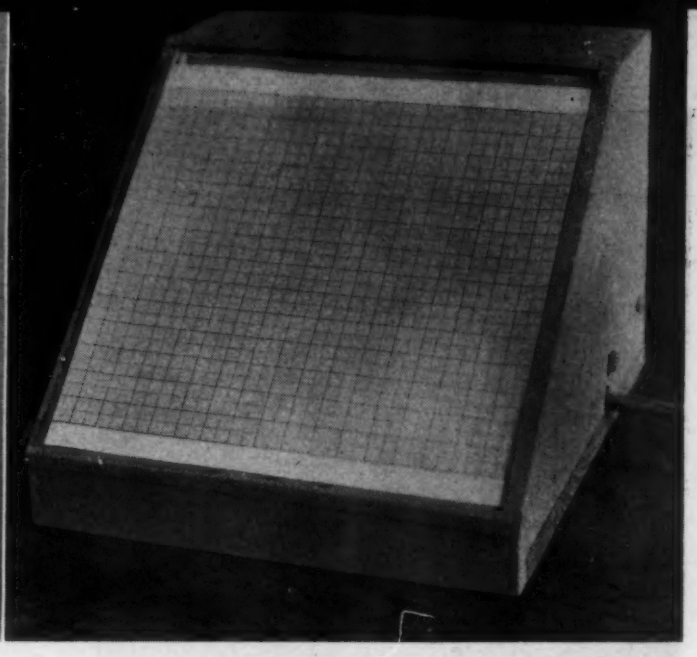


FIGURE 3—Prismatic Box with Frosted Glass and Millimeter Graph Paper Used in Reading Samples.

the literature. Schweyer and Howell[2] describe a method for determining the stain number of asphalts, but this test is at best a semi-quantitative one and is not readily applicable to petrolatums and similar products. The Dutch Pharmacopoeia has attempted to solve this problem with the so-called "Crater test." A hole is dug in a beaker of solidified petrolatum and the amount of oil appearing in this hole after a 24-hour period is taken as a rough measure of the bleeding tendency of the sample. Again this method is only qualitative and it does not rate petrolatums in the sequence in which actual practice places them.

This laboratory has, therefore, devised a simple, reproducible and quantitative test which has been used successfully for several years in plant control of the quality of our petrolatums; it is designated as the "bleeding number test."

Theory

Petrolatum can be divided into two general classes: Hypothetical and practical. We can visualize that a hypothetical petrolatum in the solid state is a gel with oil in the inner phase and wax in the outer phase. This oil can be designated as "oil of gelation." Such a petrolatum, which may contain as much as 25 percent oil, has little or no tendency to bleed at room temperature. However, such a hypothetical petrolatum would be relatively hard—too hard for actual use at room temperature, and it would therefore have little application in the pharmaceutical and cosmetic industries.

The practical petrolatum is merely a hypothetical petrolatum having more oil than can be contained in the inner phase of the gel structure. This type of petrolatum is relatively soft and exhibits the property of bleeding at room temperature; and this tendency depends on the amount of oil in excess of the "oil of gelation" present. This excess oil no doubt occurs on the outer phase possibly as an adsorbed layer on the wax-oil micelles. However, since petrolatums of the same consistency (hardness) and of the same oil content, may show widely differing tendencies to bleed, it is quite probable that different petrolatums contain different amounts of oil of gelation. Hence different samples of petrolatum used in the pharmaceutical and cosmetic industries having consistencies between 170 and 250 (ASTM Designation D937-47T) will be found to have different bleeding numbers.

Determination of Bleeding Number

Here is the method for the determination of bleeding number:

Heat the sample in a beaker to 200° F. and allow it to cool with gentle stirring until the sample is 20° F. above its melting point. Dip a section of glass tubing (4 mm. ± 0.5 mm. internal diameter, 1 mm. ± 0.2 wall thickness) into the sample for 1 to 2 minutes. Remove the tubing keeping the upper end closed with a finger so that approximately a 1-inch column of the molten sample remains in the tubing. With the lower end of the tubing about ½ inch above the standard filter paper, (Whatman No. 1, 12.5 cm. diameter) allow 3 to 5 evenly spaced drops, depending on the bleeding tendency of the sample, to fall on the paper. When the drops solidify, place the paper on a watch glass in a thermostatically controlled oven kept 30° C. ± 0.5° C. (86° F ± 1° F) for 24 hours (Figure 1). The drops should be circular of 6-8 mm. diameter (Figure 2).

After 24 hours the excess oil will have formed a ring surrounding the drop of petrolatum. Determine the outer diameter of this ring and subtract the diameter of the petrolatum drop. The difference in millimeters is designated as the bleeding number. This determination can be carried out either by the used of calipers or by the use of the apparatus illustrated in Figure 3. This apparatus consists of a prismatic box provided with a frosted glass having a millimeter graph paper superimposed thereon. Illumination is provided with a 50-watt lamp (Figures 3 and 4).

At least three readings are taken and averaged. Individual results should not vary by more than one millimeter. It has been found that the diameter of the tubing used is not a critical factor since a variation in .2 millimeters in diameter changed the magnitude of the results by 2 millimeters maximum. Similarly it has been found that the

TABLE 1

Bleeding Numbers of Some Petrolatums

SAMPLE	M. P., °C.	Viscosity @ 210° F.	Consistency	Bleeding No.
Petrolatum A	51.5	82	56	1
Petrolatum B	61.5	100	91	1.5
Petrolatum C	51.5	97	153	6
Petrolatum D	46.5	71	185	11*
Petrolatum E	48	66	190	14
Petrolatum F	55	50	190	16
Petrolatum G	43	61	210	18
Mineral Jelly I	38	52	170	30†
Mineral Jelly H	39	50	180	38

* Figure 5. † Figure 4.

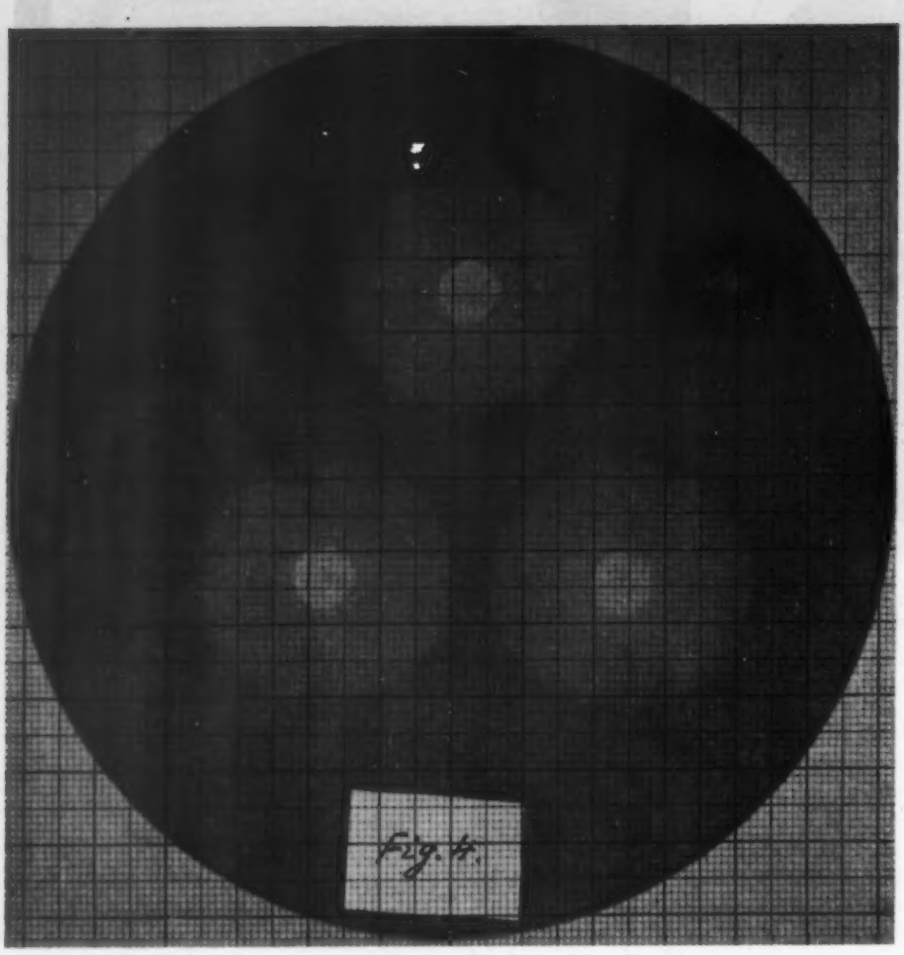


FIGURE 4

Typical tests to determine bleeding numbers of petrolatum. (Above reproduction is 94 percent actual size.)

size of the individual petrolatum drops had only a slight influence on the bleeding number, since drops of 6 and 8 millimeters gave results within 2 millimeters. Some typical tests are illustrated in Figures 4 and 5.

Experimental Data

In Table 1 are listed the bleeding numbers of various petrolatums. The melting points were taken according to ASTM D938-47T; the viscosities are all Saybolt Universal (ASTM D88-44); and the consistencies according to ASTM D937-47T.

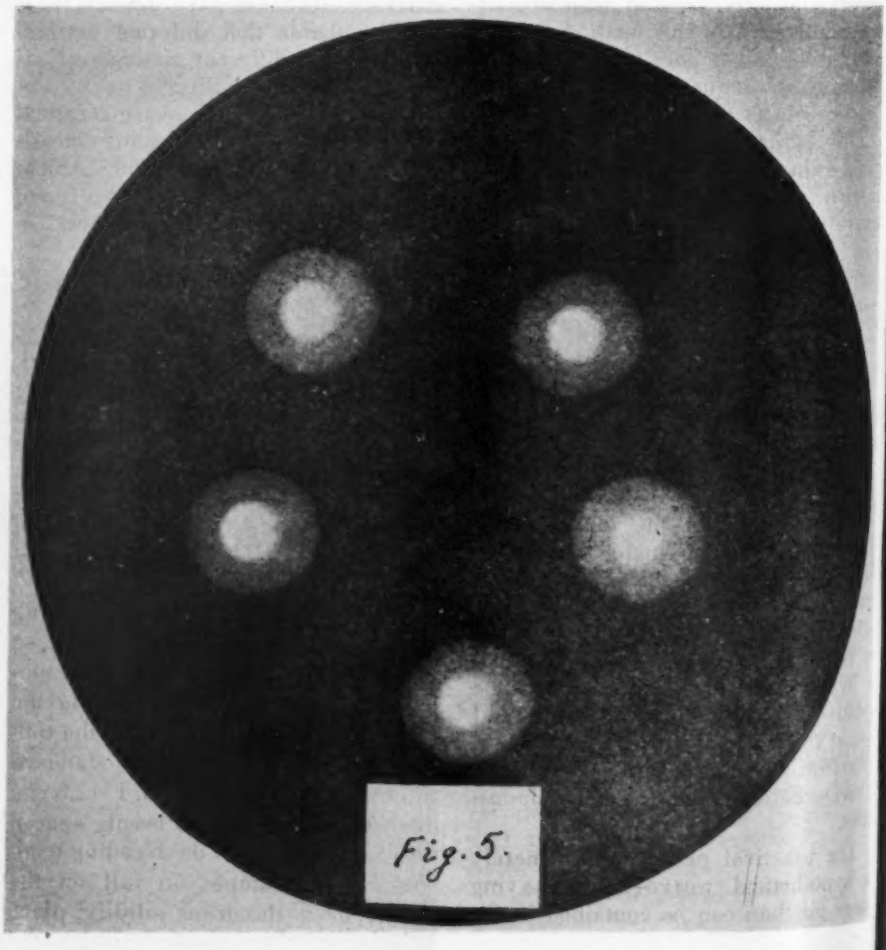
The data in Table I show that the bleeding number rates the petrolatum in the correct sequence. As previously mentioned, the hypothetical petrolatums would have a zero bleeding number. All practical petrolatums bleed, but in general hard petrolatums bleed less than do soft ones. The melting point and viscosity of petrolatums have no appreciable influence on the bleeding number, and none should be expected since neither is an indication of the oil content (in excess of oil of gelation).

The bleeding number of a petrolatum depends on the temperature at which the test is run. Higher temperatures yield greater bleeding numbers. This would be expected since the difference between liquid and solid hydrocarbons is not a sharp one. Some of the hydrocarbons in petrolatum which are solid at 20° C. may be liquid at 30° C. As the temperature of the test approaches the melting point of the petrolatum this conversion of solid to liquid hydrocarbons occurs to such an extent as to give unduly high results. On the other hand, when the test is run at low temperatures many of the hydrocarbons which in actual usage behave as oils are converted into solids and the results are misleadingly low, as is exemplified in Table 2.

The data in Table 2 indicate that as the temperature is raised from 25° C. to 40° C. the highest melting point petrolatum shows the smallest relative increase in bleeding number, so that at the latter temperature Petrolatum F has a lower number than Petrolatum E. However, from actual experience we know that Petrolatum F has a slightly greater staining tendency. At 25° C. Petrolatum G shows a lower

FIGURE 5

Typical bleeding number petrolatum tests, showing original drops and rings around each. (Reproduction is 94 percent actual size.)



bleeding number than Petrolatum F, although the former is known to have a greater staining tendency in actual practice. However, at 30° C. the samples are all in the correct sequence. Hence this temperature was chosen as the condition for running the test. Incidentally this is the temperature which dermatologists consider as the average of the skin—an important factor when petrolatum is used as an ointment.

The length of time during which the bleeding number is run has an influence on the magnitude of the results obtained. Since it can be shown that the time vs. bleeding number curve (Figure 6) of one petrolatum does not cross that of another, the time of bleeding is not significant. A long enough time should be allowed in order to permit reasonably large differences between samples and yet not be so long as to make the test unwieldy. Hence the 24-hour interval was chosen.

Comparison with Crater Test

Obviously if the bleeding number test is found to yield results roughly parallel to a different method, then the dependability of the former method is strengthened. Hence the Dutch Pharmacopoeia Crater Test (loc. cit.) was made on several petrolatums as follows: Samples were poured into cans (3-inch diameter by 2-inch deep) to 0.25-inch from the rim. After the samples congealed, identical craters were formed in each by twisting therein a wedge-shaped spatula having an angle of 15° with the pointed end touching the bottom of the containers. The samples were then allowed to remain in an oven kept at 30° C. ± 0.5° C. (86° F. ± 1° F.). The depth of oil in the crater was then estimated after 24 and 96 hours. The results thereby obtained are compared with the bleeding numbers of the samples in Table 3.

Although the results of the two methods are roughly parallel, the crater test, besides being only semi-quantitative, has the following shortcomings:

a) It does not detect the staining tendency of relatively hard samples (A, B and C).

b) It is influenced by the melting point of the sample (compare Petrolatum E with Petrolatum F).

FIGURE 6

Time vs. Bleeding Number. (E, F and G are petrolatums; H is a mineral jelly).

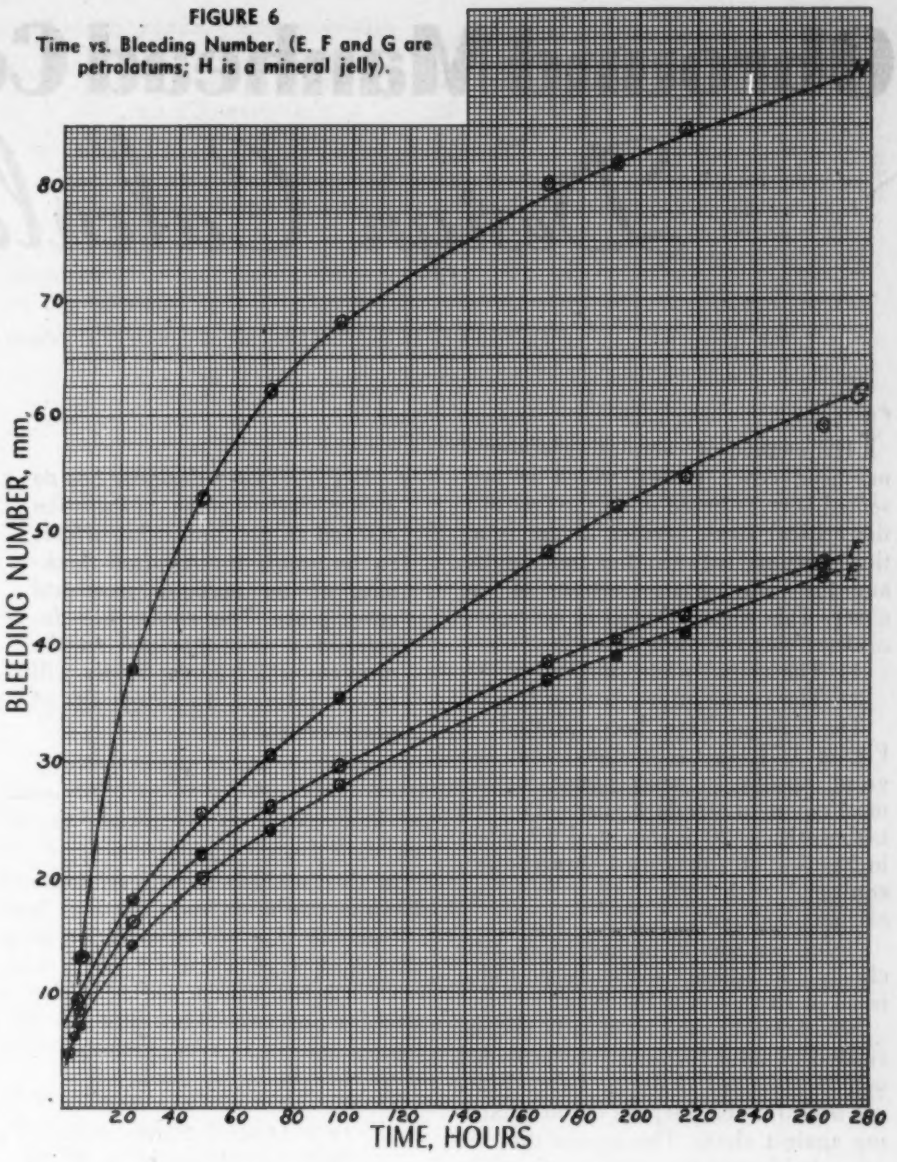


TABLE 2

Influence of Temperature on Bleeding Number

Sample			Bleeding Test Temp. (24 Hours)		
Grade	M. P., °C.	Consistency	25° C.	30° C.	40° C.
Petrolatum E	48	190	7	14	38
Petrolatum F	55	190	10	16	28
Petrolatum G	43	210	9.5	18	43
Mineral Jelly H	39	180	20	38	..

TABLE 3

Bleeding Number Vs Crater Test

SAMPLE	M.P., °C.	Consistency	Bleeding Number	CRATER TEST, mm*	
				24 Hours	96 Hours
Petrolatum A	51.5	56	1	0	0
Petrolatum B	61.5	91	1.5	0	0
Petrolatum C	51.5	153	6.0	0	0
Petrolatum E	48	190	14	5	20
Petrolatum F	55	190	16	0	5
Petrolatum G	43	210	18	20	35
Mineral Jelly H	39	180	38	35	40

* The height of oil in the craters was estimated. The data given is at best roughly quantitative.

Summary

The tendency of petrolatums and similar products to stain can be measured by the bleeding number test. When a drop of liquid petrolatum is allowed to fall on a sheet of filter paper and to congeal, a ring of oil is found to stain the paper around the drop after a time interval. The outer diameter of this ring less the diameter of the drop, obtained under standardized conditions, is called the bleeding number.

[1] Gurwitsch, L., and Moore, H., "Scientific Principles of Petroleum Technology," pp. 552-3, New York, D. Van Nostrand Co., 1932.

[2] Schweyer, H. E., and Howell, H. C., Ind. Eng. Chem., 9, 563-5 (1937).

Obround Manhead Cover Plates

Design Calculations

HARALD E. LONNGREN, Mechanical Engineer, New York

THE method of calculating obround manhead cover plates, which is presented here, is based upon the fact that the critical stress resides in the junction sections between the rectangular and the round plate portions of the cover. This means that it is necessary to determine the total stress in

1) The round plate portion.
2) The rectangular plate portion.

The results have been plotted in Figure 1. It is to be noted that the graph applies to cover plates for the most common standard sizes—12 x 18 inches, 12 x 20 inches and 12 x 24 inches — of obround manheads equipped with either alloy steel or carbon steel bolts.

Reference should be had to an article by the author in the July, 1945, issue of PETROLEUM REFINER.

Standard obround manheads, as fabricated in solid forgings, are provided with a standard drilling. Large bolts are used for the purpose of safeguarding against abuse. This means that the cover bolting is excessive, particularly when alloy steel bolts are used and the internal pressure is not high (below 300 psi.).

The API-ASME code permits the designer to use a design bolt load—W—which is equal to the average of the minimum required (W_{min}) and the actual bolt load (W_{act}).

PRESENTLY a designer has no public authoritative calculation method to aid him in his efforts to determine the required thickness of an obround manhead cover plate. The author has developed a new approach to the problem which undoubtedly will be of interest to designers of pressure parts.

In this analysis it will be assumed that the minimum required bolt load is equal to H_{GY} which condition actually holds true when a ½-inch wide steel jacketed, asbestos-filled gasket is used for pressures below 300 psi. This type of gasket is very common when alloy steel bolts are used.

Thus,

$H_{GY} = (\pi \times 14.625 + 2 \times 6) \times .25 \times 8000 = 116000$ for $12'' \times 18''$ mh.

$= (\pi \times 14.625 + 2 \times 8) \times .25 \times 8000 = 124000$ for $12'' \times 20''$ mh.

$= (\pi \times 14.625 + 2 \times 12) \times .25 \times 8000 = 140000$ for $12'' \times 24''$ mh.

The actual bolt load is,

$W_{act} = 20 \times .551 \times 20000 = 220400$ for $12'' \times 18''$ mh.

$= 20 \times .551 \times 20000 = 220400$ for $12'' \times 20''$ mh.

$= 22 \times .551 \times 20000 = 242400$ for $12'' \times 20''$ mh.

Thus,

$$W = \frac{116000 + 220400}{2} = 168000 \text{ for } 12'' \times 18'' \text{ mh.}$$

$$= \frac{120000 + 220400}{2} = 172000 \text{ for } 12'' \times 20'' \text{ mh.}$$

$$= \frac{140000 + 242400}{2} = 191000 \text{ for } 12'' \times 24'' \text{ mh.}$$

These bolt loads are uniformly distributed over the cover plate along the centerline of the gasket. Thus the design load per lineal inch is,

$$W = \frac{168000}{58} = 2900 \text{ lbs. for } 12'' \times 18'' \text{ mh.}$$

$$= \frac{172000}{62} = 2775 \text{ lbs. for } 12'' \times 20'' \text{ mh.}$$

$$= \frac{191000}{70} = 2725 \text{ lbs. for } 12'' \times 24'' \text{ mh.}$$

A reasonable average figure for all the cover plate sizes is 2750 pounds per lineal inch when alloy steel bolts are used.

When carbon steel bolts are used it is necessary to change the gasket material. For the permissible operating conditions with carbon steel bolts—160 psi. and 450° F. maximum temperature—it is customary to use a compressed asbestos gasket. The gasket width will be assumed to be ½ inch.

Thus,

$W_{min} = H_{GY} = (\pi \times 14.625 + 2 \times 6) \times .25 \times 4500 = 65250$ for $12'' \times 18''$ mh.

$= (\pi \times 14.625 + 2 \times 8) \times .25 \times 4500 = 69750$ for $12'' \times 20''$ mh.

$= (\pi \times 14.625 + 2 \times 12) \times .25 \times 4500 = 78750$ for $12'' \times 24''$ mh.

The actual bolt load is

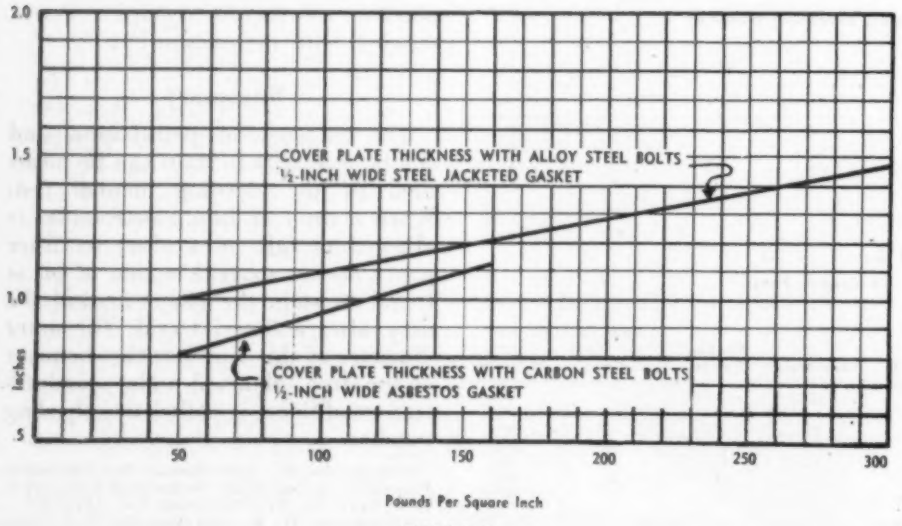


FIGURE 1

$W_{act} = 20 \times .551 \times 6875 = 75600$ for $12'' \times 18''$ mh.

$= 20 \times .551 \times 6875 = 75600$ for $12'' \times 20''$ mh.

$= 22 \times .551 \times 6875 = 83300$ for $12'' \times 24''$ mh.

Thus the design bolt load is,

$$W = \frac{65250 + 75600}{2} = 70450 \text{ for } 12'' \times 18'' \text{ mh.}$$

$$= \frac{69750 + 75600}{2} = 72700 \text{ for } 12'' \times 20'' \text{ mh.}$$

$$= \frac{78750 + 83300}{2} = 81000 \text{ for } 12'' \times 24'' \text{ mh.}$$

The bolt loads are uniformly distributed over the cover plate along the center line of the gasket. Thus the design bolt loads per lineal inch are,

$\frac{70450}{58} = 1240$ for $12'' \times 18''$ mh.

$\frac{72700}{62} = 1170$ for $12'' \times 20''$ mh.

$\frac{81000}{2} = 1150$ for $12'' \times 24''$ mh.

A reasonable average figure for all these cover plate sizes is 1150 pounds per lineal inch, when carbon steel bolts are used.

Round Plate Portion

The required thickness of the round, flat plate portion is determined by the formula

$$t_1 = d\sqrt{\frac{C_1 \times p}{S}} \text{ (per API-ASME code.)}$$

In this expression,
- d = Mean diameter of gasket.
- C_1 = Factor.
- p = Internal pressure.
- S = Allowable stress.

When the applied bolting tends to bend the plate—as the case is when a ring gasket is used—the factor C_1 is,

$$C_1 = .3 + \frac{1.4 \times W \times h_G}{H \times d}$$

in which expression,
- W = Design bolt load.
- h_G = See Figure 2.
- H = Hydrostatic end load on area bounded by the outside diameter of the gasket.
- d = Mean diameter of gasket.

The design bolt load, with alloy steel bolts, is

$W = \pi \times 14.625 \times 2750 = 126500$ lbs. (For all covers.)

thus,

$$C_1 = .3 + \frac{1.4 \times 126500 \times .813}{180 \times p \times 14.625} = .3 + \frac{55}{p} = \frac{.3p + 55}{p}$$

with carbon steel bolts,

$W = \pi \times 14.625 \times 1150 = 52900$ lbs. (For all covers.)

thus,

$$C_1 = .3 + \frac{1.4 \times 52900 \times .813}{180 \times p \times 14.625} = .3 + \frac{23}{p} = \frac{.3p + 23}{p}$$

Rectangular Plate Portion

The required thickness of the rectangular plate portion is determined by the formula,

$$t_2 = d\sqrt{\frac{C_2 \times p}{S}}$$

in which expression,
- d = Span between center lines of gasket.
- C_2 = Factor.
- p = Internal pressure.
- S = Allowable stress.

The rectangular plate portion is considered to have the long edges fixed. The short edges are supported. When the applied bolting tends to bend the plate in the direction of the long edges, the factor C_2 is

$$C_2 = .5 + \frac{W_S \times h_G}{a \times d_1 \times d \times p}$$

in which expression,
- W_S = Total design bolt load on the straight portion.
- h_G = See Figure 1.
- a = Short span.
- d_1 = Span over the outside of the gasket.
- d = Span between the center lines of the gasket.

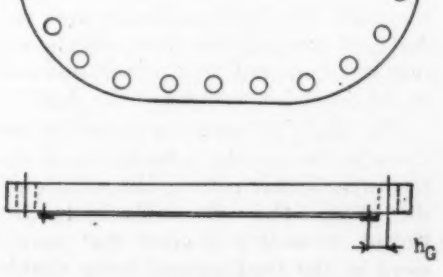


FIGURE 2

The total design bolt load—W_S—when carbon steel bolts are used is,

$W_S = 1150 \times 2 \times 6 = 13800$ for $12'' \times 18''$ mh.

$= 1150 \times 2 \times 8 = 18400$ for $12'' \times 20''$ mh.

$= 1150 \times 2 \times 12 = 27600$ for $12'' \times 24''$ mh.

Thus,

$$C_2 = .5 + \frac{33000 \times .813}{p \times 6 \times 15.125 \times 14.625} = \frac{.5p + 20}{p} \text{ for } 12'' \times 18'' \text{ mh.}$$

$$= .5 + \frac{44000 \times .813}{p \times 8 \times 15.125 \times 14.625} = \frac{.5p + 20}{p} \text{ for } 12'' \times 20'' \text{ mh.}$$

$$= .5 + \frac{66000 \times .813}{p \times 12 \times 15.125 \times 14.625} = \frac{.5p + 20}{p} \text{ for } 12'' \times 24'' \text{ mh.}$$

The total design bolt load—W_S—when alloy steel bolts are used is,

$W_S = 2750 \times 2 \times 6 = 33000$ for $12'' \times 18''$ mh.

$= 2750 \times 2 \times 8 = 44000$ for $12'' \times 20''$ mh.

$= 2750 \times 2 \times 12 = 66000$ for $12'' \times 24''$ mh.

Thus,

$$C_2 = .5 + \frac{13800 \times .813}{p \times 6 \times 15.125 \times 14.625} = \frac{.5p + 8.5}{p} \text{ for } 12'' \times 18'' \text{ mh.}$$

$$= .5 + \frac{18400 \times .813}{p \times 8 \times 15.125 \times 14.625} = \frac{.5p + 8.5}{p} \text{ for } 12'' \times 20'' \text{ mh.}$$

$$= .5 + \frac{27600 \times .813}{p \times 12 \times 15.125 \times 14.625} = \frac{.5p + 8.5}{p} \text{ for } 12'' \times 24'' \text{ mh.}$$

The relationship between t_1 and t_2 is,

$$\frac{t_1^2}{t_2^2} = \frac{C_1}{C_2}$$

or

$$t_2 = t_1\sqrt{\frac{C_2}{C_1}}$$

It will be seen that $t_1 = t_2$ when $C_1 = C_2$. The pressure which corresponds to this condition is,

$.3p + 55 = .5p + 20$

$p = 175$ psi (for alloy bolts)

This pressure represents the border line. For pressures below 175 psi. it will thus be seen that the required cover plate thickness is found per formula,

$$t = d\sqrt{\frac{C_1 p}{S}}$$

and for pressures above 175 psi. per formula,

$$t = d\sqrt{\frac{C_2 p}{S}}$$

When carbon steel bolts are used $t_1 = t_2$ when

$.3p + 23 = .5p + 8.5$

$p = 72$ psi.

Removing Spent Catalyst From Reactor Tubes

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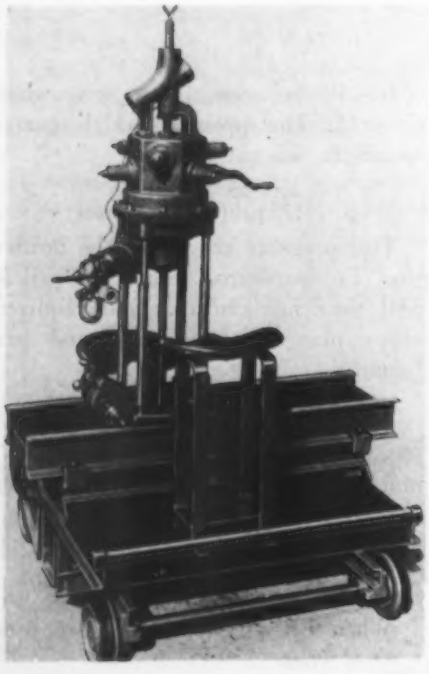
THE removal of spent catalyst from reactor tower tubes by drilling presents a problem which justifies the expense of designing and building of equipment to perform this maintenance operation. The substance to be removed is toxic and corrosive and must be confined during and after removal. Confinement of the cuttings did not pose any particular problem but it was desired to greatly speed up the drilling and handling rate.

To assure rapid drilling for any condition of catalyst likely to be encountered, the equipment was powered by an air motor which develops 5 H.P. at 2500 rpm on air pressure of 90 psi. This motor is of the same six-blade, valved air intake design used for the standard series air motors. The drive is through a 7.5 to 1 worm gear reduction operating in an oil bath.

Experience indicates that a drilling speed of twelve to fourteen feet per minute may be expected as normal for average conditions. The drill is forced up through the catalyst by a feed arrangement controlled by an operator who sets the rate and direction of feed. Power for feeding is obtained from the drive motor.



Drilling machine designed to remove spent catalyst from reactor tower tubes.

The feed force may be exerted in either direction, up or down, and can exceed 600 lbs. For average conditions, maximum drilling speed can be obtained with a feed force between 100 to 150 lbs. After the catalyst has been drilled out, a brush may be attached to the upper end of the shaft for polishing of the tube as the shaft is withdrawn.

The superstructure upon which the drilling machine is mounted may vary according to the requirements of the individual installation. The initial installation was for a plant where the reactor tube sheet is approximately 13 feet above grade.

Large rubber-tired, ball-bearing casters, two of which are swivel type facilitate moving and positioning the equipment below the tower to be cleaned. Four screw-type jacks hold the structure in place and provide for any grading or surface irregularities. Built-in means are provided to check the levelness of the structure.

A hand operated drive positions the drilling platform beneath the subsequent tube rows as cleaning progresses.

The drilling head is mounted on a carriage which carries controls for raising and lowering the head to and from the tube sheet and traversing the width of the platform to locate the drill beneath the individual tube. A large pipe suspended from the carriage acts as a safety-well and receptacle for inactive or retracted drill shaft lengths. That part of the mechanism which rotates the shaft grips the shaft with three grooved wheels that adjust the pressure of their grip by the resistance to turning offered by the shaft. Mounted on double row radial ball bearings the three wheels are free to rotate and thus permit upward or downward movement of the shaft.

The shaft is made to move up or down by the angular adjustment of six feed-wheels that roll on the surface of the shaft. The six feed-wheels are linked in such a manner that movement of the feed control lever simultaneously tilts all six wheels the same direction and degree. As the direction of shaft rotation is constant, reversal of feed direction is done by reverse movement of the feed control lever.

Drill shaft is extra-heavy wall seamless steel tubing. Couplings are quick make and break. When cleaning, the operator watches the shaft in the machine until it stops turning, which means that the feed-wheels have withdrawn it from the grip of the drive wheels, and inserts the next length of shafting into a guide in the bottom of the head, lifts the shaft until it contacts the preceding section, gives it a quarter-twist which starts the coupling and brings the new length into contact with the drive rolls. Shaft rotation and feed begin at once. When the shaft is being withdrawn from the tube it uncouples automatically after passing through the drive rolls.

Because of the speed with which subsequent lengths of shafting can be coupled and the fact that uncoupling is done without stopping, or even slowing down, it is practical to use this type of equipment, for reactors with a tube sheet only six feet above grade.

The drill cuttings fall by gravity to a point where they can be jetted by an air or water stream into a container or settling pit. A vacuum pneumatic system has also been used to carry the spent catalyst to a disposal point. In any event, the method of disposal has no effect on drilling speed as long as there is sufficient capacity to handle the cuttings as rapidly as the drill cuts.

Drilling machine mounted on superstructure, height of which can be varied according to requirements of the individual installation.

Thermal Properties Of Petroleum Oils

Part III

EFFECT OF PRESSURE ON ENTHALPY OF PETROLEUM VAPOR

M. VAN WINKLE
Associate Professor of Chemical Engineering, University of Texas

IN RECENT papers[1,2] there have been presented charts and methods of computing enthalpies of petroleum liquids and vapors over the temperature range usually encountered in petroleum processing. The charts for the vapor enthalpy determinations are based on correlation of 100 percent flash vaporization temperature and slope of the flash curve and are extremely useful in design work where vaporization and condensation operations are involved. However, they represent enthalpy-temperature relationships at atmospheric pressure and are applicable only at that pressure. To make the charts usable over the range of pressures normally encountered in petroleum processing it was necessary to select a suitable method of correct-

THIS FINAL article of a three-part series has been preceded by "Mean Specific Heats of Petroleum Liquids and Vapors" and "Enthalpies of Petroleum Vapors at Atmospheric Pressure" which appeared in the two previous issues of *Petroleum Refiner*, respectively.

An approximate method for determining the effect of pressure on the enthalpy of petroleum vapor is presented in this chapter. Charts derived from existing correlations also are included which relate true- and pseudo-critical temperatures and pseudo-critical pressures to the 100 percent flash vaporization temperature (or dew point of the vapor) and slope of the flash curve. The enthalpy correction for pressure effect developed from these correlations is expressed graphically in terms of reduced temperature and the ratio of the enthalpy correction to reduced pressure at constant absolute pressures. Use of this approximation will not introduce serious error in determining the enthalpy of a petroleum vapor under pressure and it is somewhat easier to use than the molal enthalpy correction charts for pressure.

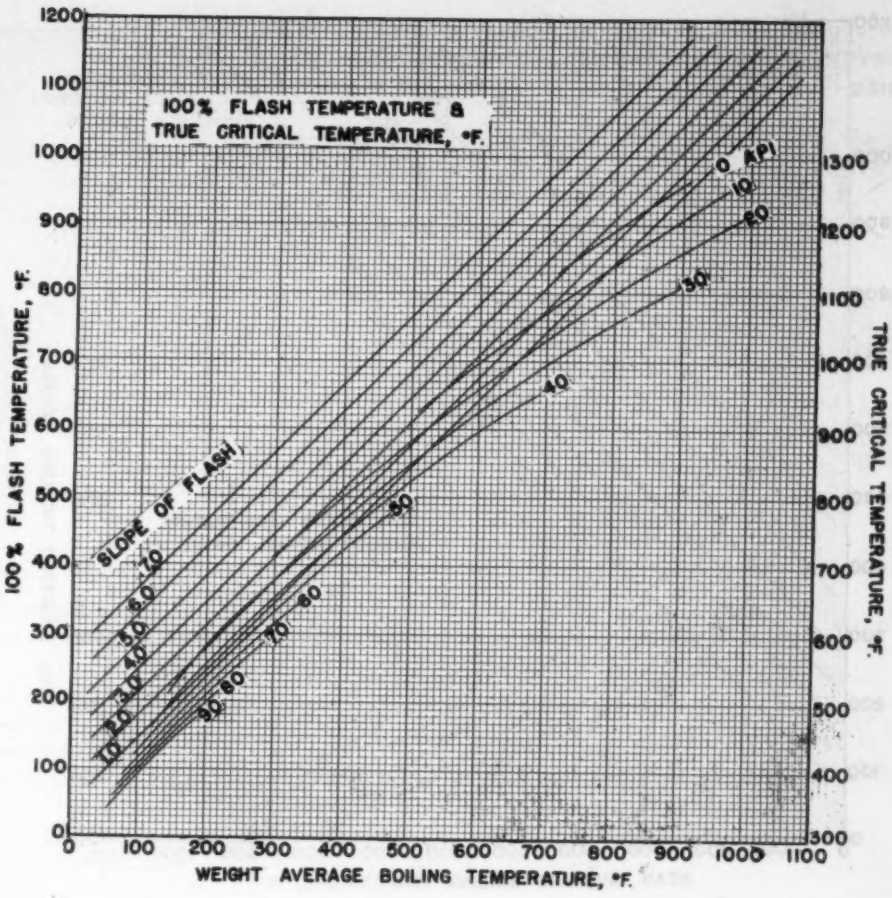


FIGURE 1

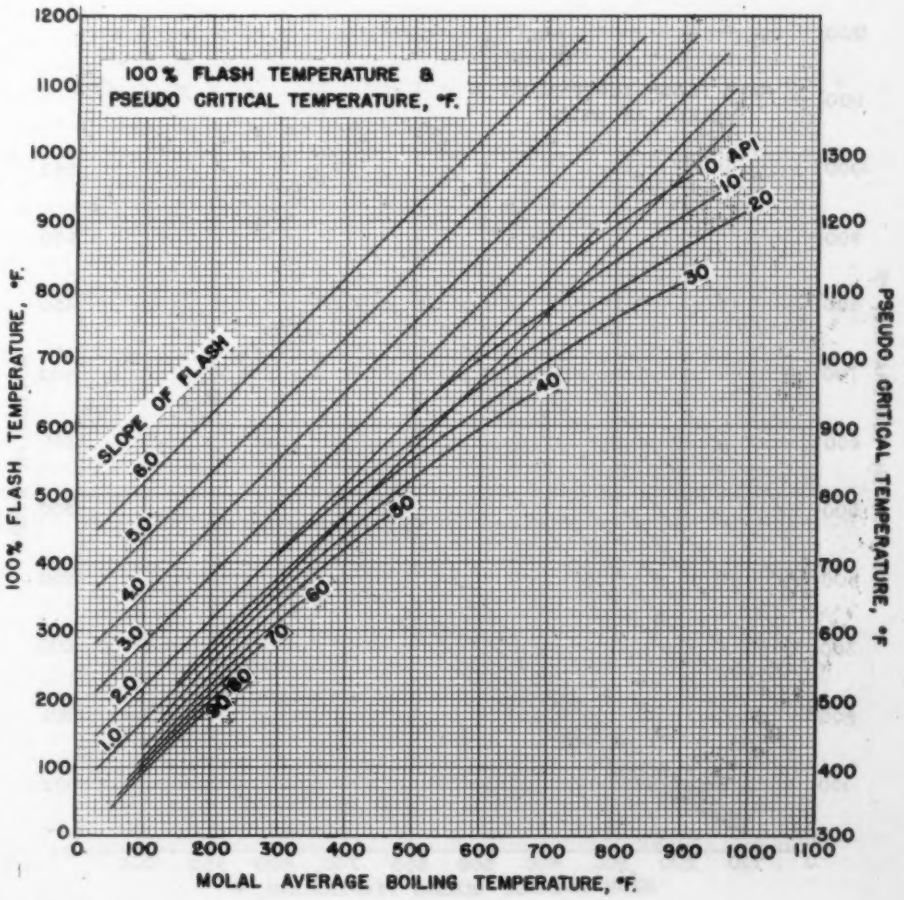


FIGURE 2

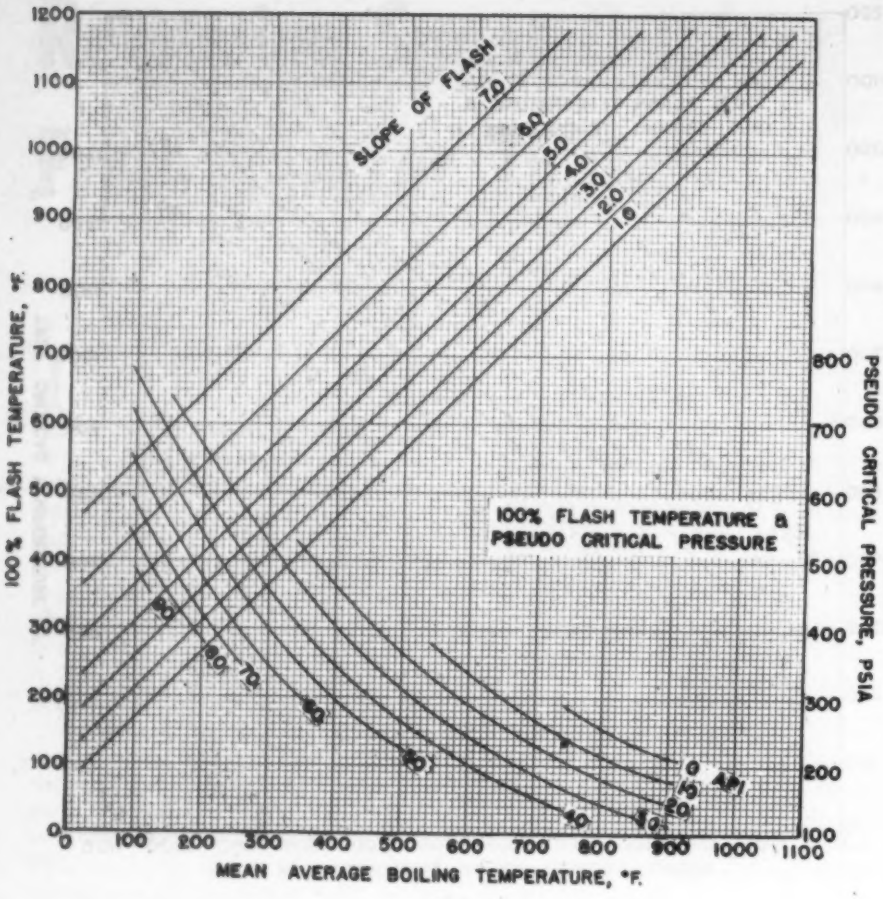


FIGURE 3

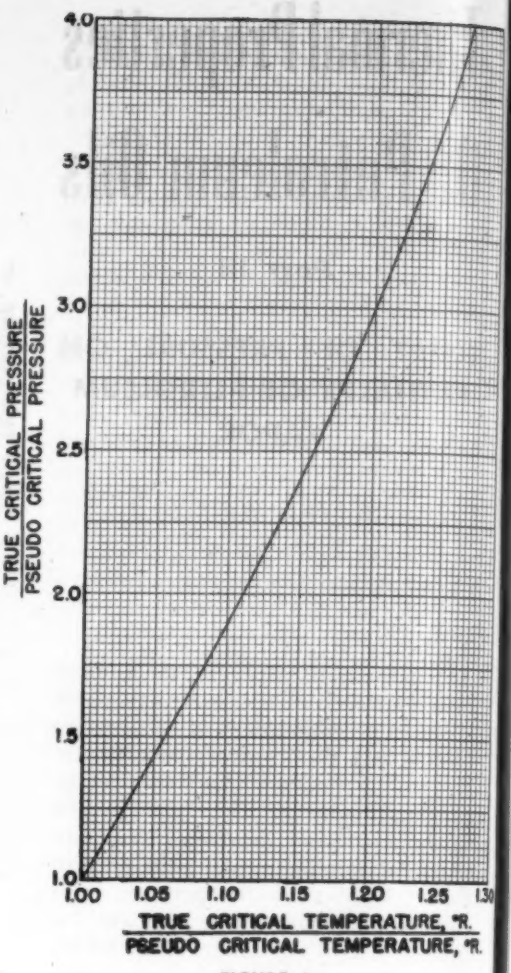


FIGURE 4

Ratio of true to pseudo critical pressure and critical temperature ratio.

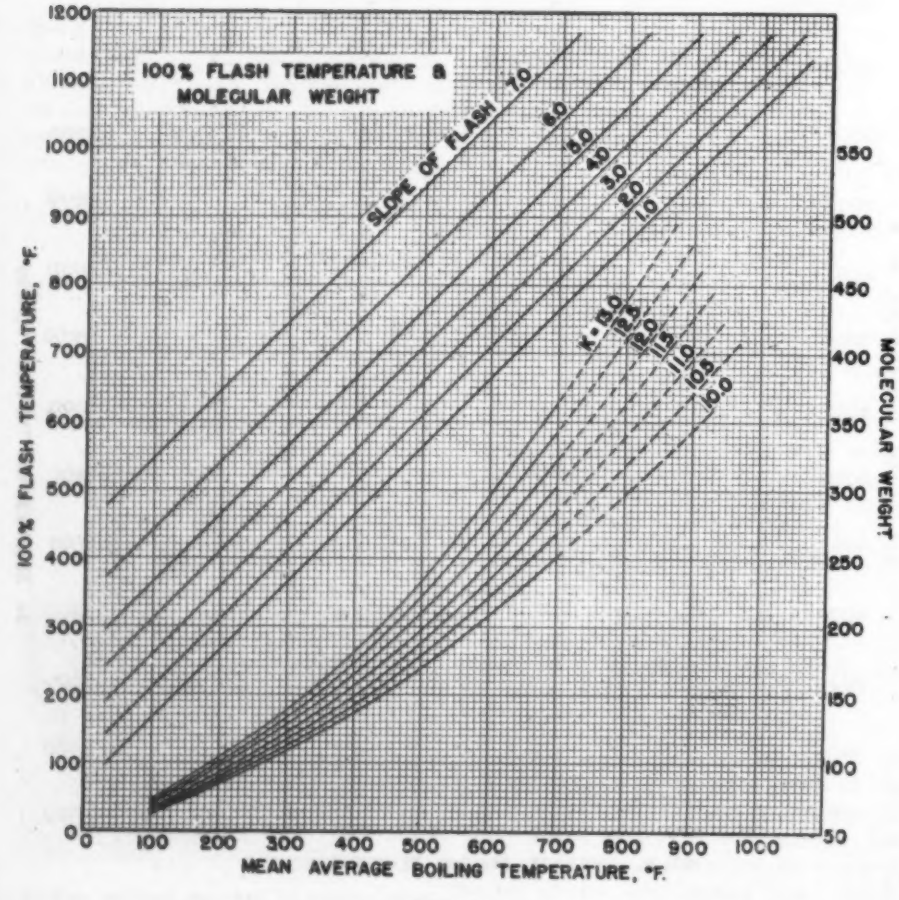


FIGURE 5

ing the enthalpies at atmospheric pressure to pressures other than atmospheric.

Various thermodynamic relationships have been developed which enable evaluation of pressure effect on enthalpy and charts presented[3,4,5] which relate molal enthalpy correction to reduced pressure and reduced temperature. The latest charts[5] are considered by the authors to have greater accuracy in the lower range of reduced temperatures and pressures than the originals and are therefore recommended. The Hougen and Watson charts were used to evaluate the corrections which are plotted in Figure 6.

It was necessary to obtain relations between critical temperature and pressure and molecular weight of petroleum vapors in terms of 100 percent flash vaporization temperature and slope of flash curve, since the enthalpy charts[2] were based on these characteristics. Figures 1, 2, and 3 correlate these characteristics with pseudo critical temperature, true critical temperature, and pseudo critical pressure respectively. Figure 4 is a re-plot of the Watson and Smith[4] correlation between

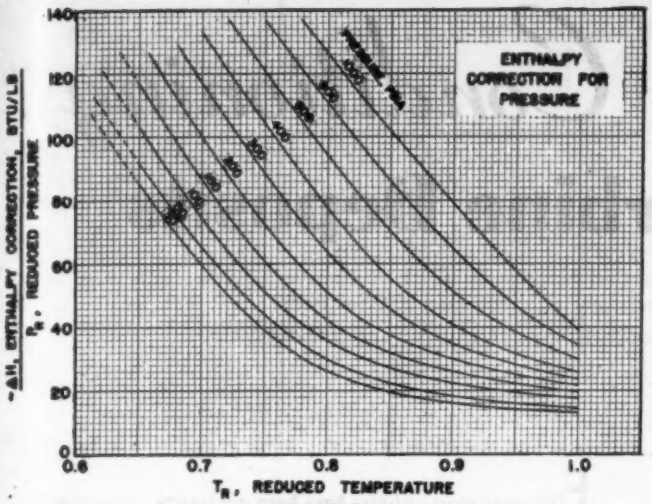


FIGURE 6

the ratios of true to pseudo critical temperature and the ratio of true to pseudo critical pressure using the recommended extrapolation.

Figure 4 was devised to give a direct relationship between flash curve characteristics and molecular weight and the basis for the chart was the existing correlation of Watson et al[6] of molecular weight, mean average, boiling point, K, and API gravity.

With Figures 1 to 5 inclusive available for simplified and rapid determination of critical temperatures, pressures and molecular weights based on vaporization characteristics, a great number of enthalpy corrections for different stocks at temperatures from 100° F. to 1000° F. and pressures from 30 to 1000 psia. were computed. Several plots were constructed from the computed data and the plot shown in Figure 6 appeared to give the most consistent correlation, although it was necessary to average and smooth the computed data to get smooth curves.

Figure 6 represents the ratio of the enthalpy correction to reduced pressure vs. reduced temperature at lines of absolute pressure. By selecting stocks of different characteristics and computing the enthalpy correction at different temperatures and pressures by means of Figure 6 and by the molal enthalpy correction chart for pressure, the maximum deviation was found to be less than 20 percent and the average deviation much less.

Because of the necessity of smoothing the computed data and the possible error introduced in such a procedure, this correlation is offered as an approximate means of determining enthalpy correction due to pressure effect on petroleum oil vapors. However, since normally the pressure effect on vapor enthalpy is relatively small compared to the total enthalpy of petroleum vapors in the usual processing temperature range the possible error introduced by the use of Figure 6 is not significant unless extreme accuracy is desired.

Example 1. Determine the enthalpy correction for a 50 API stock, flash slope = 3.0, dew point = 400° F., at a pressure of 700 psia. and 500° F.

Solution:

True critical temperature	= 620° F.	Fig. 1
Pseudo critical temperature	= 555° F.	Fig. 2
Pseudo critical pressure	= 478 psia	Fig. 3

$$\frac{T_c}{T_{pc}} = \frac{620+460}{555+460} = \frac{1080}{1015} = 1.063$$

$$\frac{P_c}{P_{pc}} = 1.55 \qquad \text{Fig. 4}$$

$$P_c = (1.55)\,(478) = 741 \text{ psia.}$$

$$P_r = \frac{700}{741} = .945$$

$$\frac{-\Delta H}{P_r} = 62 \qquad \text{Fig. 6}$$

$$\Delta H = (-62)\,(.945) = -58.5 \text{ Btu/lb.} \quad \textit{(Ans.)}$$

Example 2. Determine the enthalpy pressure correction for a 40 API vapor, dew point = 500° F., flash slope = 2.0 at a temperature of 600° F. and 200 psia.

Solution:

t_c	= 760° F.	Fig. 1
t_{pc}	= 728° F.	Fig. 2
p_{pc}	= 357 psia.	Fig. 3

$$\frac{T_c}{T_{pc}} = \frac{1220}{1188} = 1.027$$

$$\frac{p_c}{p_{pc}} = 1.225 \qquad \text{Fig. 4}$$

$$p_c = (1.225)\,(357) = 438$$

$$T_r = \frac{600+460}{1220} = \frac{1060}{1220} = .869$$

$$p_r = \frac{200}{438} = .457$$

$$\frac{-\Delta H}{p_r} = 34 \qquad \text{Fig. 6}$$

$$\Delta H = (-34)\,(.457) = -15.5 \text{ Btu/lb.}$$

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[2] Van Winkle, Petroleum Refiner 27, 379 (1948).
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[4] Watson and Smith, National Petroleum News, July (1936).
[5] Hougen and Watson, Chemical Process Principles, Part II, Thermodynamics, John Wiley and Sons (1947).
[6] Watson, Nelson, and Murphy, Ind. Eng. Chem. 27, 1460 (1935).

* * *

Boiler Water Conditioning
To Prevent Turbine Deposits

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FOR many years, refiners have been generating "by-product" electricity by means of high throttle pressures and topping turbines, and today there is a steadily increasing tendency toward electric power generation in the modern refinery. In addition, the advent of catalytic cracking has greatly increased the number of large turbines in process service. With the numerous turbo-compressor and turbine-driven pumping installations, turbine maintenance—and particularly the study of turbine blade deposits—has quite naturally increased in importance throughout the industry.

TO CONTRIBUTE to the solution of this maintenance problem a long-time study of steam turbine blade deposits analyzing their nature and formation by x-ray diffraction methods has been made. For these tests, conducted for the past ten years, samples were obtained from power plants operating turbines at pressures above 350 psig.

As we know, the obvious way of preventing turbine deposits is to control the boiler water so that the impurities present will not be carried over into the steam. This problem, however, is complicated by the question, "What salts are to be controlled and what are the range limits of this control?" The study of turbine blade deposits by x-ray diffraction is one way of driving a wedge into the problem where it can be opened up most readily.

Identification of deposit compounds and correlation with the various temperature zones in which they are found yields information regarding the behavior of the entrained impurities as they are rapidly cooled in passing through a turbine. Moreover, with a knowledge of the composition of the deposited compounds and conditions under which they were formed, we have a solid foundation upon which to build a theory of the mechanism of the depositing process from the point at which the impurities first entered the steam. Because of a lack of fundamental data, however, certain assumptions made must necessarily await verification at a future date.

Crystallization

X-ray diffraction studies of the components of blade deposits indicate that the majority of these materials are well crystallized compounds. From the laws of crystallization we know that these compounds crystallize from solutions which are supersaturated with respect to the deposited salt. We can, therefore, assume that the solvents carrying these salts either entered the turbine in a supersaturated condition, or became supersaturated as the solutions

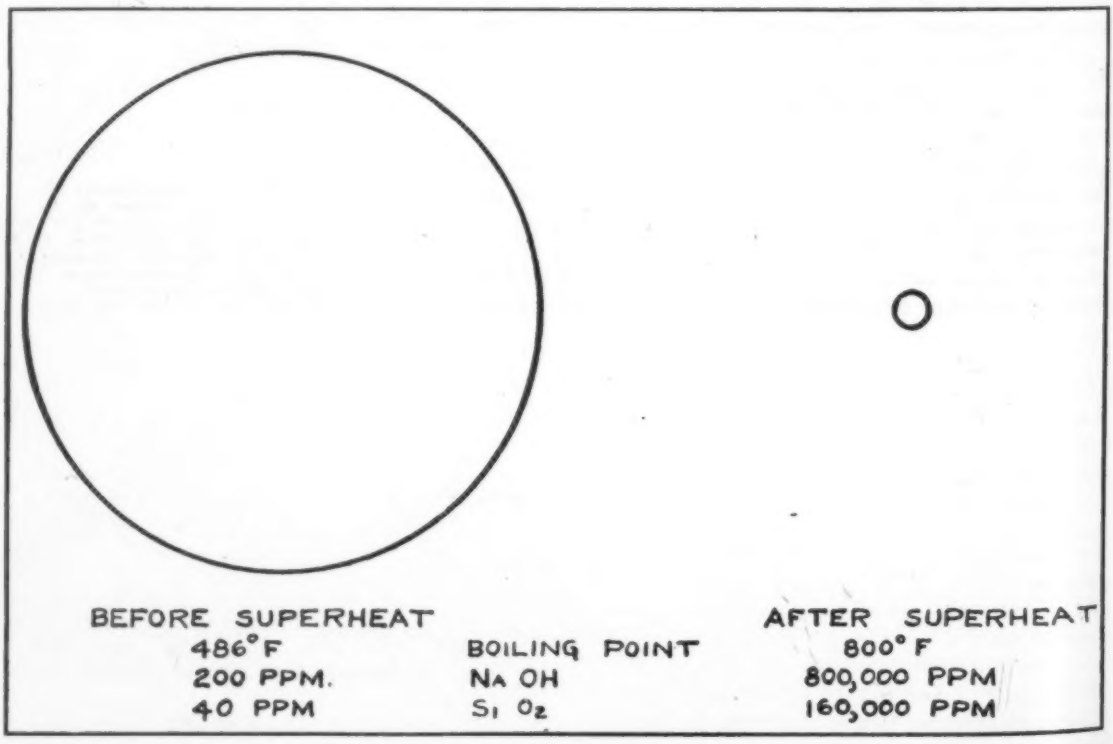

FIGURE 1
Relative Sizes of Boiler Fog Particles Before and After Superheating. (High Magnification.)

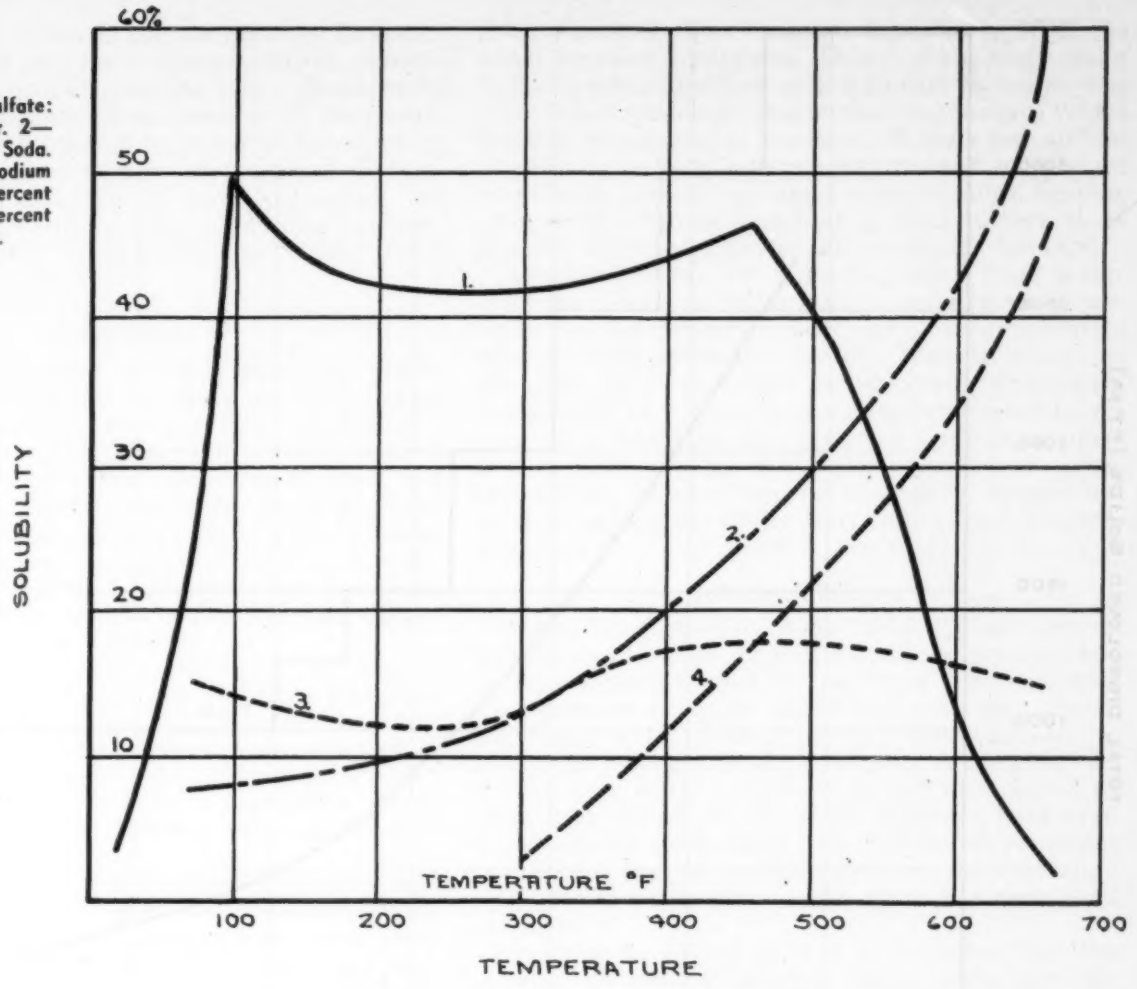

FIGURE 2
Solubility of Sodium Sulfate: 1—In Distilled Water. 2—In 25 Percent Caustic Soda. 3—In 25 Percent Sodium Chloride. 4—In 25 Percent Caustic Soda and 25 Percent Sodium Chloride.

cooled. The solvents under consideration are either superheated steam or water droplets entrained in the steam or both. In any case the solvent must become supersaturated with respect to the salts, and our mechanism must account for the concentration of salts to this saturation value.

This requirement for crystallization is not specific in regard to the solution from which precipitation takes place. The same law holds for the precipitation of solids from gases, solids from aqueous liquids and solids from molten liquids. None of these three possible solution media can be excluded from consideration in establishing a mechanism for crystallization of compounds on turbine blades.

Concentration of Impurities

Consideration of the processes occurring between the boiler and turbine permits considerable speculation on the mechanism involved. In the front drum of a boiler we have a relatively weak solution of sodium hydroxide, sodium carbonate, sodium phosphate, sodium silicate, sodium sulfate and possibly sodium nitrate and sodium sulfite. Large volumes of gaseous steam are bubbling up through the water contained in this drum, and a certain amount of foam exists on the top of this liquid bed. Depending upon the stability of these foam bubbles, the foam layer may be only a few inches high or it may attain a thickness of a foot or so. When these bubbles break, the collapsing of the film leaves very finely divided droplets suspended in the flow of steam coming up from the water beneath. When these droplets are very small, such as one might expect in fog, the downward effect of gravity is very small compared with the suspending effect of the steam traveling in an upward direction.

The smallest, most finely divided of the droplets are not removed by mechanical scrubbers and purifiers and pass over into the superheater. The droplet, in passing through the superheater, begins to boil from the increased temperature. Steam is evaporated from its surface and a concentration of salts takes place within the droplet itself.

It is well known that dissolved salts increase the boiling point of liquids up to the point of salt saturation. The same phenomenon appears in our fog droplets; the salts concentrate until the boiling point of the droplet solution is just equal to the superheated steam temperature. It may be possible that certain soluble salts have become insoluble and have precipitated out of solution in the interior of the droplet. It is also quite probable that this droplet has not gone entirely to dryness, for most boiler water contains caustic soda and it is practically impossible to dry caustic soda completely under the high steam pressures to which the droplet is subjected.

For example, in Figure 1, let us magnify a microscopic droplet and let us suppose that it contains the following composition before it goes to the superheater:

Sodium hydroxide	200 ppm
Silica	40 ppm
Boiling point	486° F.

This is a very dilute solution and far from any solubility limits. Suppose now that the smaller circle represents the size of a droplet after it had passed to the superheater, and we would find the composi-

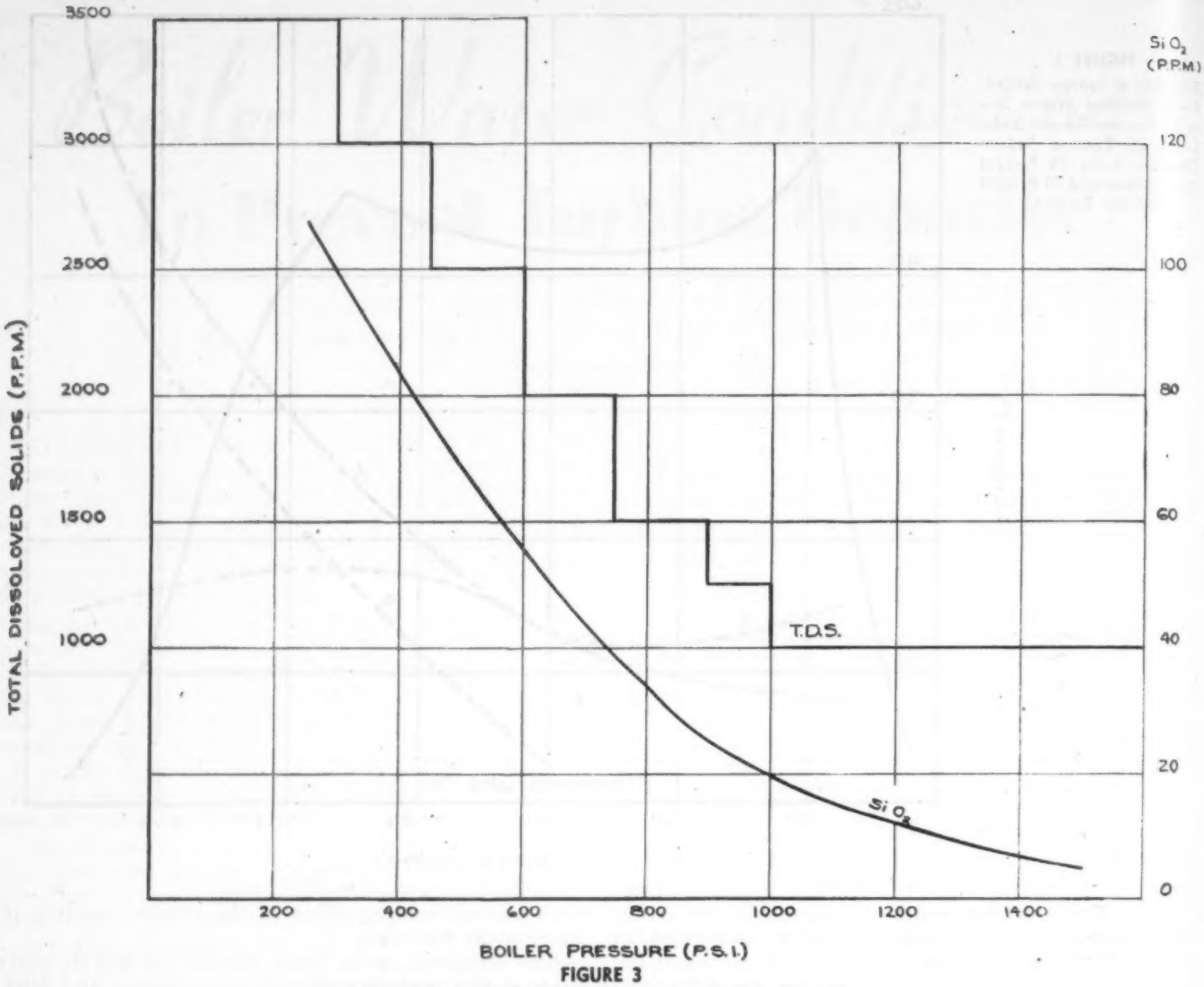

FIGURE 3

Practical Limits for Boiler Concentrations at Various Pressures.

tion to be greatly changed, possibly in the order as shown below:

800,000 ppm.....Sodium Hydroxide
160,000 ppm.....Silica
Boiling point.....800° F.

This microscopic droplet is now a very concentrated solution of caustic soda and silica. As it passes through the turbine, it undergoes simultaneously a reduction in temperature and a large number of changes of direction of movement. These directional changes take place much more often than when passing through a scrubber or a superheater.

The probability, therefore, of contacting a metal surface is much higher. Once a metal surface is contacted, this surface becomes wetted with the concentrated droplet solution. The droplet contains sodium silicate (from sodium hydroxide and silica) and by loss of heat soon reaches a supersaturated state, and crystallization begins to take place on the metallic surface. Similar droplets impinging at the same point cause this deposit to grow and finally build up to the thickness to which it can be recognized as a turbine blade deposit.

The actual concentrations in the concentrated droplet are not known because of the lack of solubility data for the system $Na_2O \cdot SiO_2 \cdot H_2O$. A solo solution of sodium hydroxide under the above stated conditions would have a concentration of about 90 percent with no solid crystallizing out. One of the unsolved problems is to determine solubility data in complex systems containing all of the boiler-water salts.

To illustrate how the presence of other salts can alter solubility relationships, the solubility of sodium sulfate is represented in Figure 2. Curve 1 represents the solubility in distilled water; curve 2 the solubility in 25 percent caustic; curve 3 the solubility in 25 percent sodium chloride; curve 4 the solubility in a combination of the 25 percent caustic soda and 25 percent sodium chloride.

It will be seen that the solubility of sodium sulfate changes as much as 400-600 percent depending upon which salts are present in solution with it. The determination of solubilities of various combinations of boiler-water salts is a very large project in itself.

Vaporization

The carryover of boiler water droplets, their concentration, and subsequent crystallization of salts therefrom, explains one way in which blade deposits can be formed. There is, however, still another way in which dissolved salts can be carried over into the turbine and that is by means of direct vaporization into the steam itself.

Professor F. G. Straub at University of Illinois has measured the solubility of silica in steam coming from a boiler water having various concentrations of sodium silicates. His results show that the solu-

bility of silica increases as the temperature increases and also indicates that there is somewhat of an equilibrium relationship between the silica dissolved in the boiler water and the silica dissolved in the steam.

We see that it is, therefore, possible for silica to be present in the steam without the presence of moisture particles to carry it. In passing through the turbine the steam, being rapidly cooled, soon becomes supersaturated with its respective silica and silica begins to deposit out.

Prevention

With this background of information we might reach certain conclusions in regard to boiler-water conditioning to prevent the formation of deposits. Usually in problems involving the prevention of a crystallization reaction, the answer is to keep the concentrations below the solubility limits for that particular salt whose crystallization is undesirable. In the case of turbine deposits, it would mean keeping the concentration of sodium silicate, silica, sodium chloride and sodium sulfate below their respective saturation levels in the steam.

Little is known of the solubility limits of the salts concentrating in droplets, but a tentative limit has been arrived at for silica dissolved in steam. In many plants it has been found that if the concentration in the steam is held below 0.1 ppm, silica deposits will be greatly minimized. There are a few plants where deposits form from steam carrying substantially less than this amount.

The manner in which water droplets become entrained in steam is one of mechanics more than chemistry, and the boiler manufacturers have made considerable progress in the design of scrubbers and purifiers to keep entrainment to a minimum. To keep steam concentrations to a minimum it is, therefore, necessary to keep the salt concentrations in the boiler water as low as possible and still operate to keep the boiler free from scale.

Since diffraction studies show that the major components of blade deposits, in turbines operating at 400 psi. and higher, are silicates, the first requirement for high pressure boiler water conditioning to prevent turbine deposits is to keep the silica concentration below a certain maximum level. This level depends upon the boiler pressure and the pH value of the boiler water. There are to date no theoretical studies by which this maximum can be derived, and limits drawn from experience are so varied that it is difficult to establish them.

Concentration Limits

Figure 3 gives the limits of total solids concentration recommended by American Boiler Manufacturers Association for pressures between 300 and 1500 psi. Much experience data has been used in arriving at those limits. On the same graph is also drawn a rough limit for silica concentrations. It is to be understood that this does not represent the values above which turbine blade deposits will be experienced or below which blade deposits will not be experienced, but shows the order of magnitude of silica concentrations in boilers of many successfully operated plants.

The silica concentration in the boiler many times cannot be controlled in any other way except by controlling the blowdown. Many plants blow down entirely according to the silica concentrations in the boiler. Plants having primary treating systems are able to control silica by removing it in some of the water treating equipment. This is done most easily in hot process lime and soda softeners by employing chemicals containing considerable magnesium. Water supplies containing as much as 58 parts per million of silica have been satisfactorily treated to produce an effluent containing only 2 ppm. of silica. Serious silica scale conditions as well as silica turbine blade deposits were corrected in this particular instance.

Another process for removing silica from water is by the use of cation and anion exchangers. Quantitatively this process appears to be more effective than the adsorption hot process, because values of the order of .1 ppm. can be obtained. Magnesium compounds have also been successfully used to reduce silica internally in a boiler. A large plant operated at 1200 psi. has eliminated quartz and amorphous silica turbine deposits by feeding magnesium oxide to reduce the boiler water silica from 20 ppm. before treatment to about 3 ppm. after treatment.

Soluble Additives

It has been observed that turbine blade deposit difficulties in plants located inland are greater than in those located around the sea coast. The one notable difference between inland and sea coast plants, where sea water is used through the condenser, is that small leakages in the condenser cause chlorides in the boiler water to become higher than would be normal for inland plants. Some engineers have even added chlorides and claim considerable improvement from their use. A sodium chloride concentration equal to six times that of the silica has been used successfully.

Referring to Figure 2, it is to be noted that the presence of sodium chloride very considerably affected the solubility of sodium sulfate and it is quite possible that sodium chloride would also affect the solubility of other salts such as the sodium silicates. It is entirely possible that sodium chloride exerts this effect where it has been found successful.

Another salt which has been added with announced success, is sodium sulfite. Some operators who have added sulfite even though it increased the amount of solids in the steam, found that the total overall crystallization on the blades was less than when no sulfite was used. Again the action of this added sulfite could be similar to that of added chloride.

The use of anti-foam materials should be of some benefit in helping to reduce the number of droplets carried over into the steam but they would not reduce the silica which is dissolved in steam.

Conclusions

In conclusion, the prevention of turbine blade deposits, particularly those of silica, depends upon keeping the silica concentration in the boiler water sufficiently low so that the concentration in the steam is less than a tenth of a part per million. This may be accomplished by one of several means such as adsorption by material added directly to the boiler and by deconcentration by blowdown.

For control of the steam solids other than silica, the recommendations of American Boiler Manufacturers Association serve as a good guide. Added salts, such as sodium chloride and sodium sulfite, have been effective in certain applications, but more basic data is needed on their effects in combination with other boiler water salts before they can be generally applied for the purpose of preventing blade deposits.

Determination Of Olefines In Cracked Gases

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THE determination of olefines in refinery cracked gases is complicated by the solubility of paraffins in concentrated sulphuric acid. The authors have investigated several reagents and have developed a procedure which, while somewhat more complicated than the usual methods, gives satisfactory and reproducible results.

THE usual orsat analysis of cracked refinery gases involves the separate volumetric determination of acid gases, olefines higher than ethylene (i.e. propene and the butenes) and ethylene. The method commonly employed[1] uses caustic potash solution to absorb acid gases, 87 percent sulphuric acid to absorb higher olefines and bromine water followed by caustic potash or sodium sulphite to remove residual olefines (ethylene).

In this paper this method is examined and various improvements are suggested.

We can enumerate the desired properties of the reagents for the olefine absorption as follows:—

1) The olefines should be dissolved completely and irreversibly under the conditions of the test.
2) The absorption should be reasonably rapid.
3) The reagent should not dissolve or react with any other constituents of the cracked refinery gases.
4) The reagent or the reaction products should have no tendency to vapourize or to liberate gaseous products.
5) The reaction products should either be soluble in the reagent or, if precipitated, should be of such nature as not to clog the pipet or otherwise interfere with the test.
6) The reaction products should not alter the solubility characteristics of the reagent with respect to the other constituents of the gas.

The available reagents for the absorption of the higher olefines and of the total olefines have been examined in the light of these requirements.

Determination of Higher Olefines

The only reagent known to absorb higher olefines completely without appreciably removing ethylene is 87 percent sulphuric acid. Davis and Quiggle[2] found that five passes of the gas through the reagent removed about 90 per cent of the higher olefines, whereas another five passes were needed to remove the rest. Ethylene was unaffected by this treatment. Other workers used two passes each of three minutes duration into a bead pipet, this procedure being the standard generally adopted in refinery practice.

The results obtained by passing a sample of a propane—butane fraction into 87 percent sulphuric acid in a bead pipet for various times are given in Table 1 and Figure 1. These results confirm the method of passing the gas into the pipet for two three-minute spells. The need for the second pass is obviously due to the fact that, with the longer times, the acid has drained from the beads after three to four minutes.

Ellis[3] states that fuming sulphuric acid dissolves some gaseous paraffins. In this work it was observed that 87 percent sulphuric acid reversibly absorbed some component of the cracked gases. On

TABLE 1
Effect of Contact Time on Absorption of Higher Olefines in 87% Sulphuric Acid

Time of Contact	Solubility in 87 Percent Acid	Decrease After Removal of Residual Olefines	Solubility in 87 Percent Acid Corrected For Butane
0	Nil	19.8%	Nil.
0.5 min.	6.8%	19.2%	7.4%
1 min.	9.0%	19.0%	9.8%
2 min.	13.0%	19.2%	13.6%
3 min.	15.2%	19.9%	15.2%
4 min.	16.2%	20.0%	16.0%
5 min.	17.0%	20.2%	16.6%
3 min. and 1 min.	19.8%	21.0%	18.6%
3 min. and 2 min.	19.6%	19.8%	19.6%

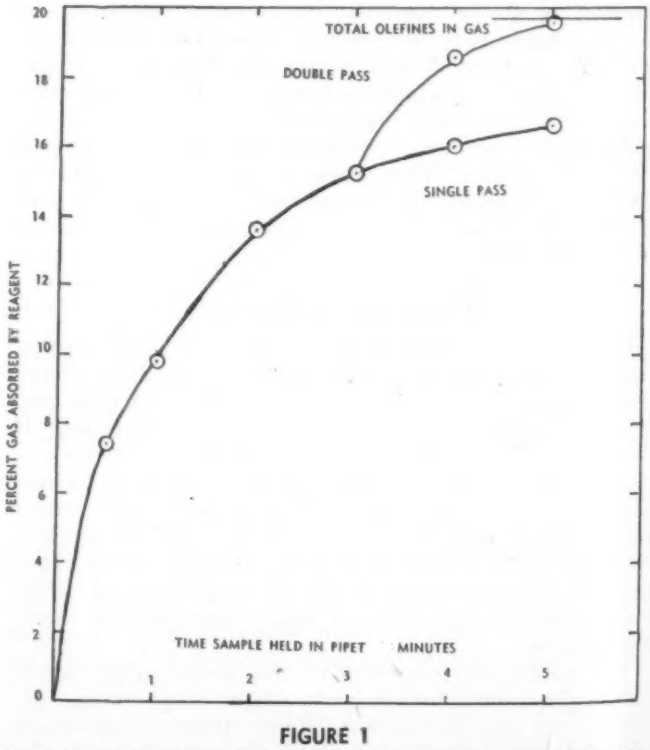

FIGURE 1
Effect of time of contact in bead pipet containing 87 percent sulphuric acid on the olefine absorption (Table 1).

"washing" the used sulphuric acid with air by keeping 50 mls of air in contact with the acid in the bead pipet for one minute, large volume increases were noted. (Table 2, Figure 2.)

From these results it can be seen that it is the solubility of butane in the reagent which is mainly responsible for this trouble. The long "tail" obtained when thus washing the old acid that had absorbed 1500 mls of olefines is probably due to the slow diffusion of the dissolved gases throughout the bulk of the reagent contained in the pipet.

As no alternative method for the absorption of higher olefines could be found, it was decided to determine them as the difference between total olefines and the residual ethylene. The ethylene was determined by absorption in the mercuric sulphate reagent (see later) after the higher olefines had been removed by 87 percent sulphuric acid, the total olefines being determined on a separate sample. In this manner the absorption or desorption of butane by the sulphuric acid should have no effect on the final result.

Table 3 shows some values obtained for the higher olefine content of gas samples by this method compared with values obtained by direct absorption in 87 percent sulphuric acid. The consistently high results for gases rich in butane and low results in relatively butane free samples substantiate the assumption that butane is dissolved in the 87 percent acid.

Data were collected for the history of a charge of 87 percent sulphuric acid used for routine process testing of cracking plant gases covering a wide range of gas composition. A total of 1264 mls. of gas were absorbed by the reagent, of which 1252 mls were olefines. Since as much as 8 mls. of butane can be dissolved from a butane sample this amply confirms that absorption and desorption of the paraffins, principally butane, occur with each sample analysed.

TABLE 2
Amount of Gas Washed from 87% Sulphuric Acid With Successive 50 ml. Portions of Air

No. of Washes	MLS. OF GAS RECOVERED		
	Old Acid After C_3-C_4	Fresh Acid After C_4	Fresh Acid After C_3
1	3.2	7.4	1.4
2	2.0	2.0	0.6
3	1.2	0.5	0.2
4	0.8	0.4	0.1
5	1.0	0.2	0.0
6	0.6	0.0	....
7	0.8	....	....
8	0.8	....	....
9	0.6	....	....
10	0.4	....	....
11	0.3	....	....
12	0.4	....	....
13	0.4	....	....
14	0.4	....	....
15	0.4	....	....

What is really required is a new reagent that will readily dissolve propene and the higher olefines but which does not dissolve ethylene and butane or other undesired gases.

Determination of Total Olefines

Various reagents have been recommended for the complete removal of olefines. These include concentrated sulphuric acid catalysed by nickel sulphate, silver sulphate [2,4], Vanadic acid, and Uranyl sulphate[5]; bromine water of various concentrations ([6] and others); concentrated potassium permanganate solution[7]; solutions of various mercury salts such as the nitrate[8]; sulphate[9]; and acetate[10]. Qualitative tests on the absorption of olefines by various reagents were carried out by bubbling butane gas containing about 15 percent of olefines through about 10 mls. of the solution in a 100 ml Erlenmayer flask. The flask was then closed tightly with a stopper containing a U type mercury manonmeter and shaken. The rate of the drop of the pressure was a good indication of the ab-

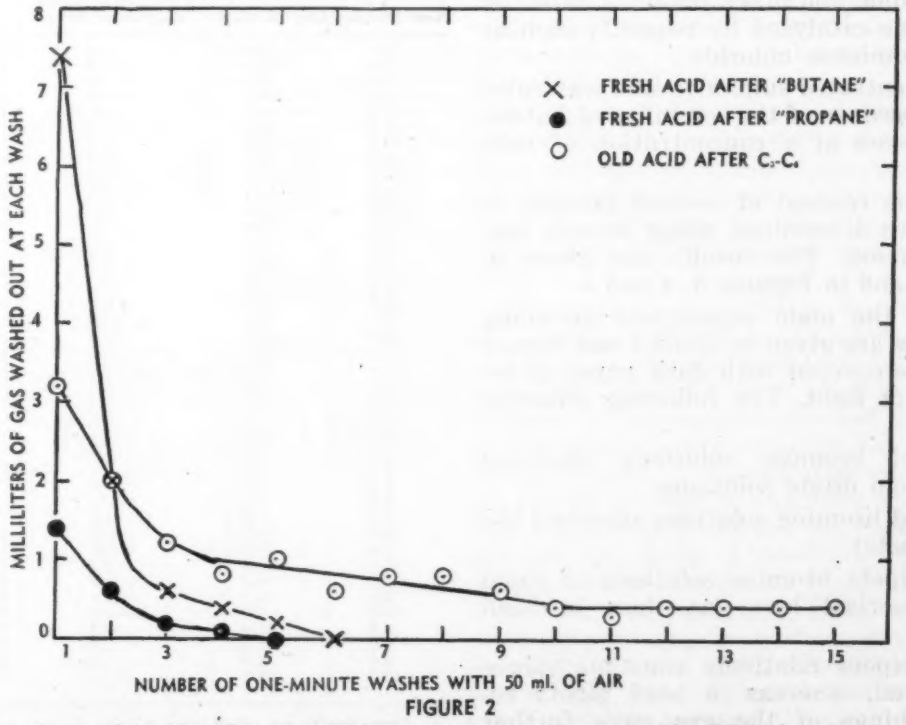

FIGURE 2
Results of "washing" 87 percent sulphuric acid reagent with separate 50 milliliters lots of air (Table 2).

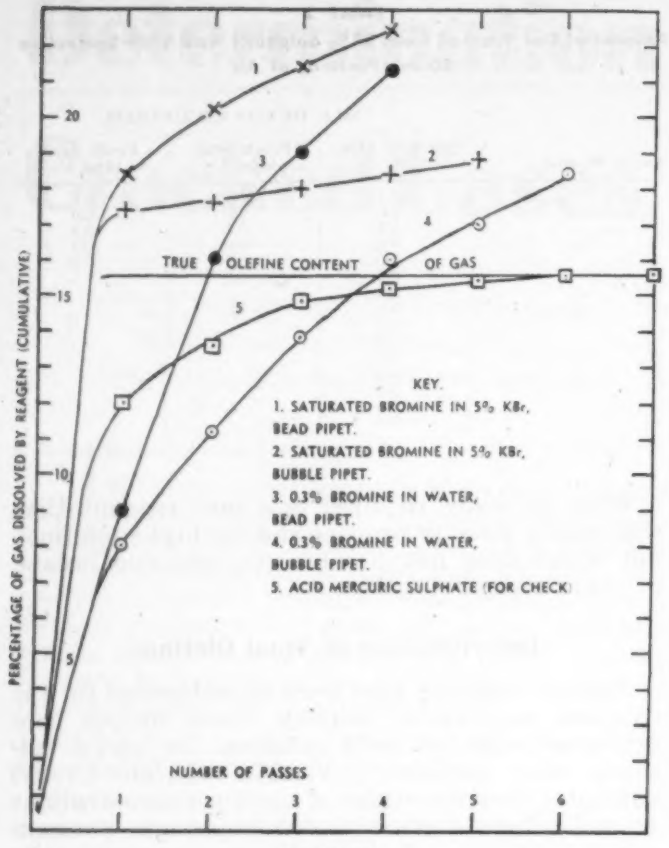
PERCENTAGE OF GAS DISSOLVED BY REAGENT (CUMULATIVE)
NUMBER OF PASSES
TRUE OLEFINE CONTENT OF GAS
KEY.
1. SATURATED BROMINE IN 5% KBr, BEAD PIPET.
2. SATURATED BROMINE IN 5% KBr, BUBBLE PIPET.
3. 0.3% BROMINE IN WATER, BEAD PIPET.
4. 0.3% BROMINE IN WATER, BUBBLE PIPET.
5. ACID MERCURIC SULPHATE (FOR CHECK)

FIGURE 3

Olefine absorption from plant butane using bromine reagents. (Table 4.)

sorptive power of the solution. By means of this test unlikely reagents were discarded after a minimum of wasted time and effort. Some of the reagents thus discarded were:

Potassium Mercuric Iodine—5% solution.

Mercuric Cyanide—5% solution.

Acid pottassium dichromate—saturated solution.

Potassium triiodide and other reagents based on the action of iodine catalysed by reagents such as ferric chloride aluminum chloride.

The use of concentrated sulphuric acid was ruled out immediately because of the solubility of butane in this reagent even at a concentration of only 87 percent.

The total olefine content of several samples of cracked gases were determined using various reagents for comparison. The results are given in Tables 4, 5 and 6 and in Figures 3, 4 and 5.

The results of the main experiment involving the use of bromine are given in Table 4 and Figure 3. All pipets were covered with dark paper to reduce the effects of light. The following observations were made:

a) Concentrated bromine solutions absorbed more gas than dilute solutions.

b) Concentrated bromine solutions absorbed the gas much faster.

c) In bubble pipets bromine solutions of equal strength absorbed less gas than in bead pipets.

d) In bubble pipets relatively constant values were obtained, whereas in bead pipets repeated washings of the gas gave further volume decrease.

e) The caustic soda solution used to remove bromine vapours from the gas should contain sodium sulphite or phenol to reduce hypobromite formation, as otherwise errors due to oxygen evolution (from the decompositions of the hyprobromite) may occur.

f) When using bromine all results obtained were much higher than the actual olefine content as determined by the mercuric sulphate reagent of Francis and Lukasiewicz.

Some Substitution of the Paraffins

Those results point to the assumption that some substitution of the paraffins always occurs concurrently with the addition of the bromine to the double bond; further substitution is probably catalysed by the surface of the glass beads. From these results and Lange's[7] observation of the solubility of paraffins in bromine water it can be seen that this is not a suitable reagent for the determination of olefines.

With acid, neutral, and alkaline permanganate solution the absorption was rather slow and the results somewhat lower than those obtained by meruric sulphate solutions. In the case of the acidic solution (and possibly to a smaller extent in the case of the others) these lower results were due to the evolution of oxygen by decomposition of permanganate. Deposits of manganese dioxide in the neck of the pipette also made accurate readings difficult. (Tables 5, 6 and Figures 4 and 5.)

A suspension of bleaching powder in a sodium bicarbonate solution was found to absorb olefines very slowly, the rate depending largely on the pH of the solution. The rate of absorption was too slow for the practical use of the reagent.

According to Hofmann and Sand[11] Deniges[12], and

TABLE 3

Comparison of New and Old Methods

PERCENT HIGHER OLEFINES		Mls. Paraffins Taken Up By 87 Percent Sulphuric Acid	Gas Sample
New Method	Old Method		
32.0	30.0	— 2.0	Poly charge
37.6	43.6	+ 5.0	Poly charge
29.2	32.2	+ 3.0	Poly charge
32.3	36.2	+ 4.0	Poly charge
38.2	36.6	— 1.6	Poly charge
36.8	35.6	— 1.2	Poly charge
37.6	36.6	— 1.0	Poly charge
33.8	33.6	— 0.2	Poly charge
39.8	41.0	+ 1.2	Poly charge
37.8	35.4	— 2.4	Poly charge
25.2	26.2	+ 1.0	Poly after reactors
17.4	16.4	— 0.8	Poly after reactors
13.4	15.4	+ 2.0	Poly after reactors
17.8	25.2	+ 7.4	Poly after reactors
14.2	15.6	+ 0.6	Poly after reactors
17.2	16.6	— 0.6	Poly after reactors
28.8	28.3	— 0.6	Poly after reactors
17.4	16.8	— 0.6	Poly after reactors
25.0	28.6	— 0.4	Poly after reactors
15.4	16.4	— 0.8	Poly after reactors
13.0	7.4	— 5.6	Waste gas before absorbers
11.8	8.0	— 3.8	Waste gas before absorbers
12.8	9.9	— 3.4	Waste gas before absorbers
15.2	11.4	— 3.8	Waste gas before absorbers
16.8	16.4	— 0.4	Waste gas before absorbers
7.0	4.6	— 2.8	Waste gas after absorbers
8.2	4.6	— 3.6	Waste gas after absorbers
9.4	4.6	— 4.8	Waste gas after absorbers
7.4	7.0	— 0.4	Waste gas after absorbers
7.8	6.6	+ 1.2	Waste gas after absorbers
18.4	25.0	+ 6.6	Butane
32.4	35.0	+ 2.6	Butane
22.4	27.6	+ 5.2	Butane
13.2	20.0	+ 5.8	Butane
19.6	25.0	+ 5.4	Butane
20.0	4.0	—15.2	Propene
18.8	16.4	— 2.4	Propene
4.0	2.0	— 2.0	Propene
9.6	8.0	— 1.6	Propene
15.0	13.2	— 1.8	Propene

These results are taken from routine process analyses. The observed differences between the two methods are therefore conditioned largely by the previous sample analyzed.

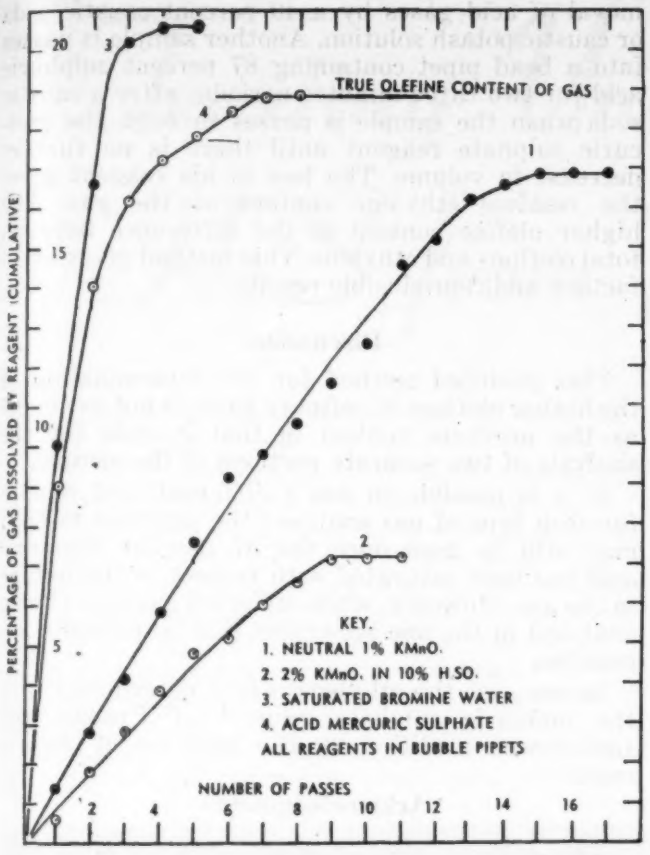
TRUE OLEFINE CONTENT OF GAS
PERCENTAGE OF GAS DISSOLVED BY REAGENT (CUMULATIVE)
NUMBER OF PASSES
KEY.
1. NEUTRAL 1% KMnO4
2. 2% KMnO4 IN 10% H2SO4
3. SATURATED BROMINE WATER
4. ACID MERCURIC SULPHATE
ALL REAGENTS IN BUBBLE PIPETS

FIGURE 4
Olefine absorption from plant butane using various reagents (Table 5).

Balbiano[13] most mercuric salts give addition compounds with olefines. These olefine-mercury compounds are claimed to have the following type structure[11]:

X -Hg - CHR - CHR[1] -OH.

TABLE 4
Absorption of Olefines in Bromine

No. of Passes	SAT. Br_2 IN 5 PERCENT KBr		0.3 PERCENT Br_2 IN WATER		Mercuric Sulphate (Check)
	Bead Pipet	Bubble Pipet	Bead Pipet	Bubble Pipet	
1	18.4%	17.4%	9.0%	8.0%	12.0%
2	20.2%	17.6%	16.0%	11.2%	13.6%
3	21.4%	18.0%	19.0%	13.8%	14.8%
4	22.4%	18.4%	21.0%	16.0%	15.2%
5	.....	18.8%	.....	17.0%	15.4%
6	.....	.....	.....	18.4%	15.6%
7	.....	.....	.....	.....	15.6%
Time of pass	½ min.	½ min.	5 min.	3 times ½ min.	½ min.

TABLE 5
Absorption of Olefines from Refinery "Butane" by Various Reagents in Bubble Pipets

No. of Passes	Neutral 1 Percent $KMnO_4$	2 Percent $KMnO_4$ in 10 Percent H_2SO_4	Sat. Bromine Water	$HgSO_4$ in 22 Percent H_2SO_4
1	1.4	0.6	10.0	9.0
2	2.8	1.8	16.6	14.0
3	4.2	2.8	20.2	16.2
4	5.8	3.8	20.6	17.2
5	7.6	4.8	20.6	17.8
6	9.2	5.2	....	18.4
7	9.8	6.0	....	18.8
8	10.6	6.6	....	18.8
9	11.6	7.2	....	....
10	12.6	7.2	....	....
11	14.6	7.2	....	....
12	15.2	(Passed into	....	....
13	16.2	bromine water	....	....
14	16.6	and NaOH	....	....
15	16.8	gave 9.6%)	....	....
16	16.8	....	....	....
17	16.8	....	....	....

It has been claimed that the presence of the hydrated mercuric ion is necessary for this reaction to take place. In this work solutions of mercuric cyanide and potassium mercuric iodide were examined and found to be inactive. This confirmed that the reaction takes place between the olefine and the mercuric ion rather than the covalent or co-ordinated mercury atom.

A solution of mercuric acetate in dilute acetic acid absorbed olefines readily but the reaction was either somewhat reversible or some paraffin solution took place, as on "washing" the solution with air, some gas was given up.

A solution of mercuric sulphate in 22 percent sulphuric acid[9] or mercuric nitrate in dilute nitric acid less than 3N with or without the addition of sodium dichromate, absorbed olefines fairly quickly and irreversibly. No appreciable solution of paraffins could be detected by "washing" the solutions with air. Pale yellow sulphate and nitrate precipitates and an orange dichromate precipitate were obtained.

TABLE 6
Absorption of Olefines from Refinery "Butane" by Various Reagents in Bubble Pipets

No. of Passes	Bleaching Powder Slurry in Sat. Na H CO 3	1 Percent $KMnO_4$ in 10 Percent NaOH	6 Percent Mercuric Acetate	Bromine Water	$Hg(NO_3)_2 + K_2Cr_2O_7$ In 2N H NO3
1	0.8	5.0	11.2	22.0	7.2
2	1.8	8.4	17.0	25.6	16.4
3	2.6	11.2	19.8	25.6	19.6
4	3.6	15.0	22.4	....	22.2
5	4.6	18.0	24.0	....	23.2
6	5.4	19.4	24.8	....	24.4
7	6.4	20.2	25.2	....	24.4
8	7.6	21.0	25.2	....	....
9	8.8	21.4	....	....	....
10	9.4	21.8	....	....	....
11	10.0	22.0	....	....	....
12	10.6	22.4	....	....	....
13	11.4	22.6	....	....	....
14	13.8	22.6	....	....	....
15	14.4	....	....	....	....
16	14.6	....	....	....	....
17	15.0	....	....	....	....
18	15.4	....	....	....	....
19	15.8	....	....	....	....
20	16.2	....	....	....	....
21	17.6	....	....	....	....

As the precipitates are soluble in strong hydrochloric and nitric acids with gas evolution the maximum acid concentration of the reagents is probably critical. An approximately three normal nitric acid solution seemed to be near the upper limit as at higher acid concentrations absorption was incomplete.

The sulphate precipitate was somewhat sticky and thus tended to clog the pipet and obscured the observation of the liquid level by adhering to the neck. The addition of a small amount of indigo carmine to the reagent improved the characteristics of the precipitate somewhat but the presence of several grams of sodium or potassium dichromate per 100 ml. of reagent was more effective. However, this only reduced and did not completely eliminate the trouble. After a period of use this reagent changed from orange to green showing that the dichromate was reduced. Since no gas evolution could be seen and no carbon dioxide could be detected in the gas after ethylene absorption it appeared that the olefine oxidation products were soluble in the reagent.

From the results of this work it can be seen

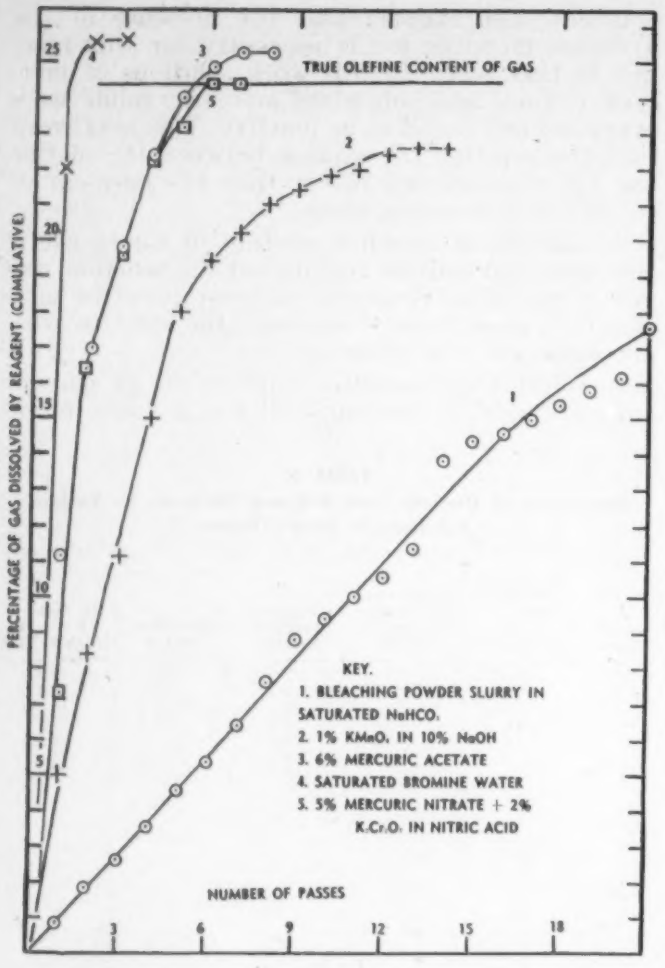
TRUE OLEFINE CONTENT OF GAS
PERCENTAGE OF GAS DISSOLVED BY REAGENT (CUMULATIVE)
NUMBER OF PASSES
KEY.
1. BLEACHING POWDER SLURRY IN SATURATED NaHCO3
2. 1% KMnO4 IN 10% NaOH
3. 6% MERCURIC ACETATE
4. SATURATED BROMINE WATER
5. 5% MERCURIC NITRATE + 2% K2Cr2O7 IN NITRIC ACID

FIGURE 5

Olefine absorption from plant butane using various reagents (Table 6).

that the mercury salts are the most promising reagents of those examined. Although the physical characteristics of the precipitate formed can occasionally be troublesome, this is not a serious factor.

Modified Method for the Determination of Higher Olefines and Ethylene

Total olefines are determined by absorptions in the mercuric sulphate-sulphuric acid reagent[9] (57g mercuric sulphate and 10g sodium dichromate in 220 mls 22 percent sulphuric acid) after the removal of acid gases by a 40 percent caustic soda or caustic potash solution. Another sample is passes into a bead pipet containing 87 percent sulphuric acid for two three minutes periods; after a caustic soda wash the sample is passes through the mercuric sulphate reagent until there is no further decrease in volume. The loss in this reagent gives the residual ethylene content of the gas. The higher olefine content is the difference between total olefines and ethylene. This method gives satisfactory and reproducible results.

Discussion

This modified method for the determination of the higher olefines in refinery gases is not as simple as the previous method in that it calls for the analysis of two separate portions of the sample.

If it is possible to use a different acid pipette for each type of gas analysed the previous method may still be used once the 87 percent sulphuric acid has been saturated with respect to the butane in the gas. However, when different gases are being analysed in the one apparatus this is normally impossible.

In any case the ethylene is best determined with the mercuric sulphate reagent of Francis and Lukasiewcz modified by the addition of dichromate.

Acknowledgments

The authors wish to acknowledge with thanks the permission granted by the management of National Oil Proprietary Ltd. for the publication of this paper, and the assistance of R. S. Neville and R. H. Beaumont in carrying out the work.

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* * *

Treating Units Eliminate H_2S from Process Gas

THIS is a description covering the main features of the method and equipment utilized by Warren Petroleum Corporation in the Salem, Ill., Plant No. 21 to eliminate corrosion difficulties in the processing of casinghead gas having an H_2S content of 95 grains per 100 cubic feet.

WARREN Petroleum Corporation is currently processing 6 million cubic feet daily of sour casinghead gas for a total production of 84,000 gallons per day of liquid products, which includes propane, isobutane, butane, and 18-pound RVP natural gasoline, in the Salem, Ill., Plant No. 21. These products are substantially free of hydrogen sulphide and pass the No. 1 copper strip test; also, corrosion of equipment using residue gas as fuel has been substantially reduced. Before installation of the treating units, corrosion had caused serious difficulties in operation of the plant.

Hydrogen sulphide and mercaptan sulfurs are removed from the gas and the products by treatment with sodium carbonate, caustic wash, and cupric chloride at various points in processing.

Inlet gas from field separators flows through an inlet scrubber and is compressed to 50 psig, as shown in the flow sheet of Figure 1. After cooling and flowing through a low-stage scrubber, the gas enters two

Photograph at left shows Warren Petroleum Corporation's Salem Plant No. 21 in Illinois. Installation of treating units at Salem where 6 million cubic feet daily of sour casinghead gas is processed, has resulted in products substantially free of hydrogen sulphide.

Photograph at right shows raw gasoline receiver from which liquid and uncondensed vapors flow to separate caustic wash equipment to reduce the hydrogen sulphide content.

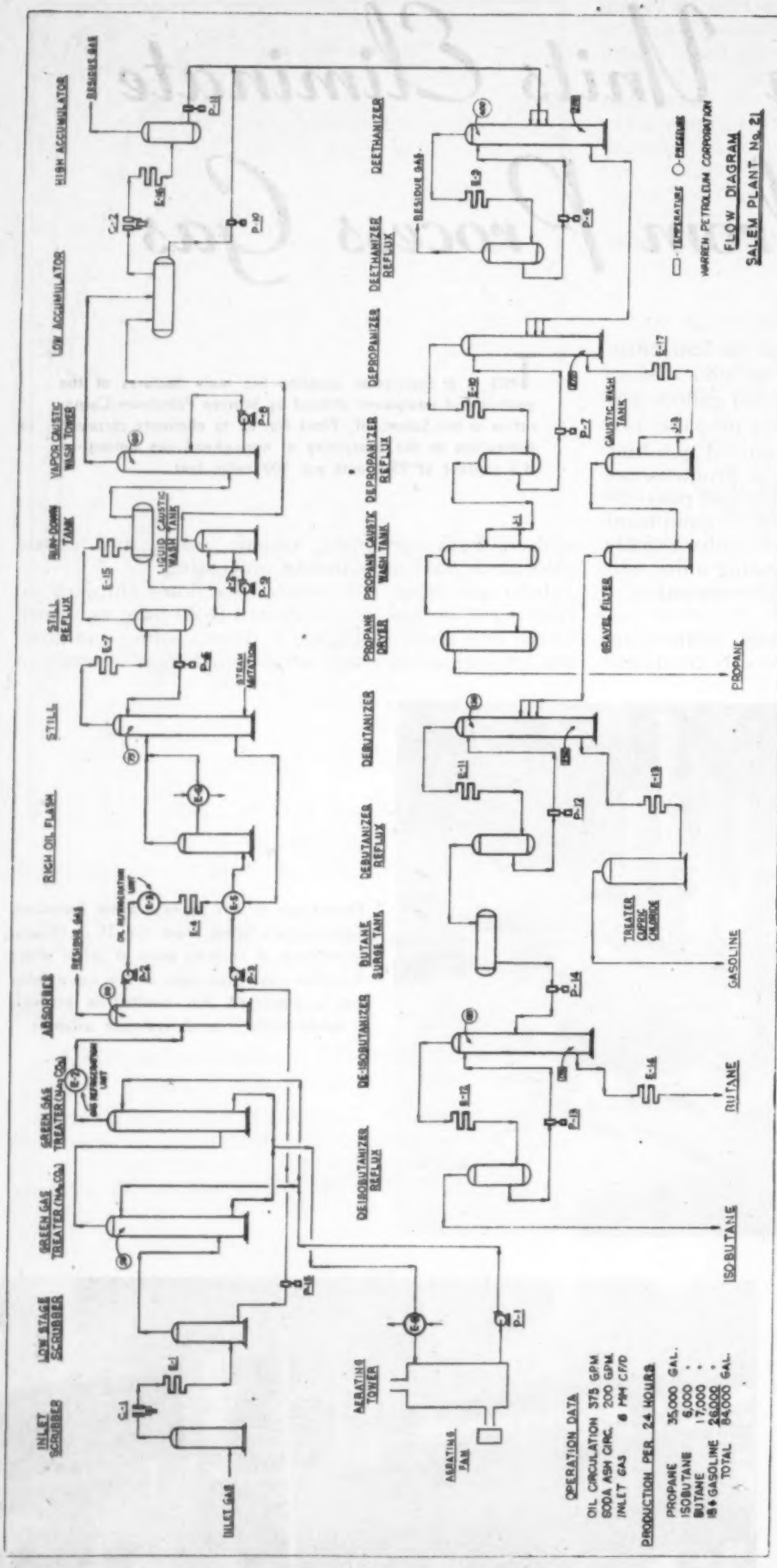


Figure 1
Flow Diagram of Salem Plant No. 21.

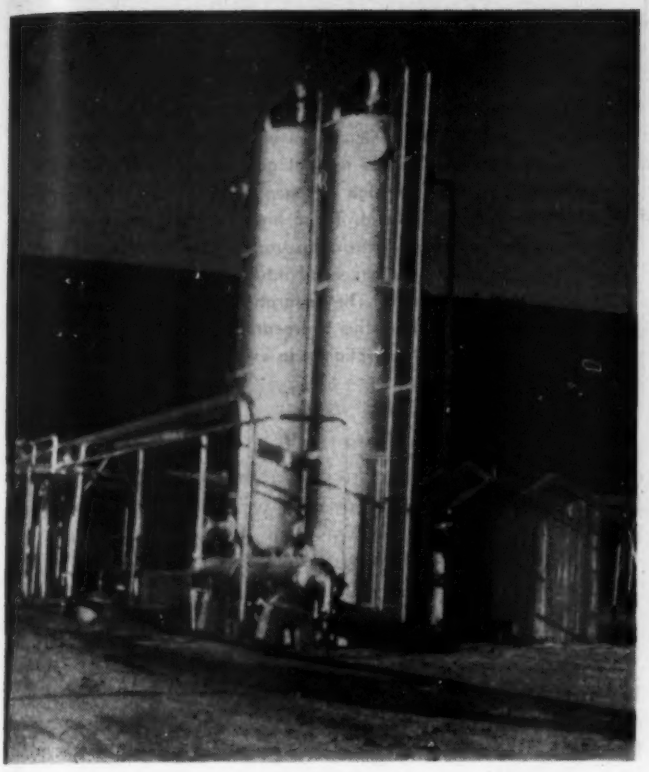
bubble plate towers connected in series for contacting with a countercurrent flowing solution of sodium carbonate, Na_2CO_3. The solution has a one percent concentration of sodium carbonate and is pumped over the towers in equal volumes at a total rate of 200 gallons per minute. The total reduction of the hydrogen sulphide content of the gas is 92 grains, 75 grains being removed in the first tower. As the towers are connected in series for the flow of gas and in parallel for the flow of sodium carbonate, the gas is contacted twice with the fresh solution.

Simple Reactivation Method

Spent sodium carbonate solution is reactivated by a relatively simple method. The liquid is pumped over an aerator tower and flows down over baffles and breaker strips placed in the tower countercurrent to a stream of air entering the bottom of the tower from a blower. This blower supplies the required volume of air at low pressure to release the hydrogen sulphide and reactivate the sodium carbonate. Reactivated liquid is collected in the base of the tower.

The gas containing 3 grains per 100 cubic feet flows to the absorber for contacting with absorption oil pumped over the tower at a rate of 375 gpm. Residue gas from the absorber is used for plant fuel, and since installation of the treating unit, is relatively free of corrosive properties. Rich oil from the bottom of the absorber and condensate from the low stage scrubber is pumped through rich-lean oil heat exchanger to the rich oil flash drum, and then passed to the still for stripping. Lean oil from the still is pumped back to the absorber and overhead product is condensed and flowed to the rundown tank.

The liquid and vapor from the rundown tank are contacted with caustic (NaOH) maintained at a strength of 15 percent by weight. Instead of an occasional check on the strength of the solution with a hydrometer only, an analysis is made frequently to maintain the desired concentration, rather than discard and replace the solution when the concentration is low. Liquid from the rundown tank is pumped to the liquid caustic wash tank, which is equipped with a jet contractor to insure mixing of the liquids. Vapor from the rundown tank are contacted with caustic



Three more photographs which depict steps taken in process which is described in the accompanying article.

Upper left shows contactors in which large percentage of hydrogen sulphide is removed from incoming gas with a sodium carbonate solution.

Upper right: Interior of compressor building in Warren Petroleum Corporation's Salem, Ill., Plant No. 21.

Photo below shows tower in which reactivation of sodium carbonate solution is effected by aeration.

in a wash tower, 3 x 61 feet, and then flow overhead to the low accumulator for recombining with the liquid from the caustic wash tank. The caustic is pumped to the tower at 3 gpm and enters on the tenth tray. Caustic carried over from the tank and the tower is drained from the low accumulator.

Propane Production

Vapor from the low accumulator passes through a second stage of compression (approximately 250 psig) and a cooling section, to the high accumulator. Vent gas from the accumulator is used for fuel and the liquid combined with the liquid from the low accumulator for charging to the deethanizer tower. This stream contains approximately one grain of H_2S per 100 cubic feet of gas. Bottoms from the deethanizer flow to the depropanizer, and the propane taken overhead. The vapors from the depropanizer flow through a caustic wash tank and then a drying tank of activated alumina to storage. Propane production is 35,000 gallons per day.

Bottoms of the depropanizer are cooled, contacted with caustic as a preliminary precautionary measure, gravel washed, and charged to the debutanizer. The debutanized gasoline is cooled and treated with cupric chloride before transferring to storage. The plant produces 26,000 gpd of 26-pound RVP gasoline. Any grade of gasoline ranging from 12 to 26 pounds RVP, can be produced.

Overhead butane vapors from the debutanizer are condensed and then pumped from the butane surge tank to the deisobutanizer tower for separation in butane as bottoms (17,000 gpd) and isobutane overhead (6000 gpd).

The units for processing and treating in the plant are instrument-controlled for simple and efficient operation. The results from the methods of treating have been satisfactory for both gas and products.

The Liquefied Gas Industry

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AS POINTED out by the author, this article will be of special interest to those who are making plans for the liquefaction and storage of natural gas. The large amounts of natural gas being blown into the air or flared can be utilized and made valuable. The great expansion of the natural gas industry will, he thinks, in time require that the high nitrogen natural gases of Hugoton and other fields be utilized. These high nitrogen gases, too low in heat value and too expensive to transport to develop markets, will be separated on the one hand into hydrocarbons and on the other hand into nitrogen. The separation will be effected by a liquefaction process and the hydrocarbon content used in the great markets without any change in existing appliances.

A STUDY has been made of the prior art, the present day practices, and the future trends of the industry of liquefied gases. The approach to the study has been made from the scientific, engineering, and patent viewpoints. The urge of the scientist has been a desire to attain the lowest possible temperatures and to prove or disprove the generally accepted theories of matter and energy. The urge of the engineer has been to develop highly efficient mechanical contrivances to produce on a commercial scale the liquefied gases which the scientist has showed to be possible as a result of his experiments. The inventor has endeavored to utilize the deductions of the scientist and engineer in some plausible way to provide for himself a period of exclusive protection covering the use of a process, and/or apparatus. The magnitude of the liquefied gas industry has resulted from the joint cooperative effort of the scientist, the engineer and the technologist. The scientific principles are old. The engineering features are well known and were covered by patents which have long since expired. The future of the industry will be predicted upon the scientific experiments, the engineering developments, and the patent disclosures, and progress will be conditioned on the development of more efficient devices by the engineer, and the discovery by the technologist of processes wherein these liquefied gases may be used to produce superior and cheaper commodities which the public requires, or can utilize.

The early events in the history of any industry are not only informative but are also highly interesting. In a sentence these events constitute the romance of the industry. Some of these significant events are herewith presented in chronological order:

In 1798 Van Marum[1] was the first to liquefy a gas by means of pressure. His experiment was designed to test the validity of Boyle's law. He used ammonia gas under pressure and succeeded in liquefying it.

Sulphur dioxide was liquefied by Monge and Clouet[2] in 1800. Super atmospheric pressure and sub-atmospheric cooling were employed.

During the period 1805-6, chlorine,[3] hydrogen chloride, and arsine[4] were liquefied by pressure and cooling. A mixture of snow and calcium chloride was used. Stromeyer liquefied arsine at a pressure of 3 atmospheres and a temperature of 0° F. Northmore liquefied chlorine at a pressure of 18 atmospheres, and hydrogen chloride at 40 atmospheres.

In 1815 Carré[5] made the first laboratory ice machine. As refrigerant concentrated aqueous ammonium hydroxide was used. The following description of his machine has been taken from Bloxam's *Chemistry*, 1903 Edition: "Gas is generated by heating a concentrated solution of ammonia in a strong iron boiler whereby it is liquefied by its own pressure in an iron receiver placed in cold water. When the boiler is taken off the fire and cooled in water, the liquefied ammonia evaporates very rapidly from the receiver back into the boiler, thereby producing so much cold that a vessel of water placed in spirits of wine contained in the cavity of the receiver, is at once congealed into ice. Seventeen grams of liquid ammonia used 5661 gr. units of heat in vaporizing.

In 1823 Sir Humphrey Davy[6] had installed apparatus for the compression and liquefaction of gases at his laboratory in the Royal Institution. He liquefied chlorine, hydrogen sulphide, and hydrogen chloride. Faraday was his assistant.

Faraday[7] began his study of gas liquefaction in 1823. His earliest method consisted of placing materials necessary to make gases sealed up in one end of a bent glass tube where heat was applied to the end in which the materials were contained, and the other end of the tube was placed in the cooling mixture of ice and salt. The liquefied gases were: chlorine, sulphur dioxide, hydrogen sulphide, cyanogen, ammonia, carbon dioxide, nitrous oxide, and hydrogen chloride.

In the period 1822-3 Cagniard de la Tour[8] was the first to intimate that all gases have critical temperatures and pressures. He reported that "at a certain (high enough) temperature a liquid under sufficient pressure becomes a vapor or gas having the same volume as the liquid itself." It was not realized at this time, or even in the life of Faraday that the solution of the liquefied gas problems involved the use of accurate themodynamic data.

In 1824 Bussi[9] was the first to use liquid sulphur dioxide in the making of ice and for the liquefaction of other gases. He employed rapid evaporation under reduced pressure.

In 1834 Thilorier[10] prepared liquid and solid carbon dioxide on a rather large scale. He used in his earlier experiments cast iron apparatus but later on changed to apparatus made of copper. These vessels functioned both as compresser and receiver. The practical incentive for Thilorier's work was the manufacture of carbonated beverages. This investigator discovered that when solid carbon dioxide was mixed

with diethyl ether that extremely low temperatures were obtainable.

In 1839 Mitchell[11] succeeded in producing a temperature —146° F. by rapidly removing the vapor from a mixture of solid carbon dioxide and diethyl ether. At this time this was the lowest temperature which had ever been produced.

In 1844 Natterer[12] compressed gases in a wrought iron vessel to approximately three thousand atmospheres pressure. The primary object of these experiments was to liquefy air, nitrogen, oxygen, and hydrogen. The secondary purpose was to determine the deviations from Boyle's law which these gases underwent when subjected to the extremely high pressures. Natterer failed in his primary object for the reason that he did not cool these gases below their critical temperatures.

In 1845 Faraday[13] resumed his systematic study. All of the best scientific information and engineering appliances which were available were used. He successfully liquefied ethylene, silicon tetrafluoride, phosphine, boron trifluoride, and solidified hydrogen bromide, hydrogen iodide, cyanogen, ammonia, sulphur dioxide, hydrogen sulphide, and nitrous oxide. Faraday used two air pumps in his experiments, one for compressing the gases and the other for the reduction of pressure on a mixture of solid carbon dioxide and ether. He obtained a temperature of —166° F. and used an alcohol thermometer in his temperature measurements. The results of Bussi's and Thilorier's experiments were confirmed. Faraday was the first experimentor to use jointly and systematically compression and refrigeration.

Joule-Thomson Effect

Almost simultaneously with the work of Faraday, Joule[14] in 1845 conducted his initial experiments to test the validity of Boyle's law. This work was continued in association with Thomson (Lord Kelvin). In 1852[15] the results of these investigators were published. Decrease in temperature which a gas shows when expanded freely through a valve or orifice is the result of internal work performed in separating the molecules farther from one another, thus overcoming the forces of attraction that operate between the molecules. The change in temperature is the well-known Joule-Thomson effect now so extensively employed in the production of extremely low temperatures and in the liquefaction of air. The discovery marked an epoch in the history of the liquefaction of gases.

In 1849 Gorrie[16] built the first compressed air ice machine.

In 1850 Berthelot[17] succeeded in compressing gaseous oxygen to a pressure of 780 atmospheres, but failed to liquefy it for the reason that he did not have it cooled below its critical temperature.

In 1857 Siemens[18] was the first to suggest the principle of the temperature interchanger. He was led to this idea by his inability to utilize "the cold in gases which had been freely expanded from one hundred atmospheres to one atmosphere." He endeavored to utilize this "cold" in heat exchangers to attain a temperature sufficient to liquefy air. The actual cooling effect of the Joule-Thomson procedure was so small, namely, 45° F., for a drop in pressure from one hundred atmospheres to one atmosphere, that this reduction could only become useful when it was associated with a temperature interchanger. The practical application of the work of Joule-Thomson and the suggestion of Siemens are the bases upon which the modern-day processes of producing liquid air, nitrogen, and oxygen are founded.

Fuel Consumption—Ice Production

In 1862 Kirk[19] made preliminary economic studies of ice manufacture and was the first to correlate ice production with fuel consumption. He found that four pounds of ice could be made by the consumption of one pound of coal. Kirk used high pressure air, which he had water-cooled and permitted to undergo free expansion, thus producing refrigeration. The spent air was repressured and used in the cycle.

In the period 1862 to 1898 Regnault[20] conducted his classical work on the determination of the specific heats of various gases and liquids. His experimental methods are today unrivaled for care and accuracy and can well be taken as a model and a standard for present-day research. He determined specific heats of gases at atmospheric pressure and determined the effect of pressure on specific heats of gases up to four atmospheres. The variations which specific heats undergo with changes of temperature and pressure were obtained. The commonly accepted ratios of specific heats for the gases: hydrogen, air, nitrogen, oxygen, carbon monoxide, carbon dioxide, steam, and methane are those of Regnault. A knowledge of specific heat relationships is necessary for all processes having to do with the use of gaseous fuels—the compression, expansion, and liquefaction of them. All problems of refrigeration are inseparably connected with those having to do with specific heat relationships.

In 1869 Andrews[21] established by his work that there was for each gas a definite temperature, known as the critical temperature, above which it could not be liquefied no matter what pressure was employed. This discovery is one of the epoch-making procedures in the liquefaction of gases and explains the failures of Berthelot and Natterer to liquefy the so-called permanent gases. In the Bakerian lecture before the Royal Society of London, Andrews was the first to publicly announce his belief in the continuity of the gaseous and liquid states of matter.

In 1871[22] Siemens was the first to suggest the use of the platinum resistance thermometer for low temperature measurements in the liquefaction of gases.

In 1873 van der Waals published at the University of Leiden, his dissertation on *The Continuity of the Liquid and Gaseous States.* In this he explained fully all of the experimental work which he had done and correlated it with the work of earlier investigators. His well-known equation was the summation of this earlier work. His studies had only begun, for on Feb. 23, 1889, he delivered a series of lectures before the Academy of Sciences in Amsterdam,[23] reviewing this earlier work and announcing results of his later labors as the "Law of Corresponding States." According to this law all substances in corresponding states behave alike, for example, isothermals, boiling points, vapor pressures, and latent heats should be identical for the liquid-gas systems at corresponding temperatures. Many lines of investigation have been suggested and occasioned by the work of van der Waals and the results of these investgations have been fundamental and of great importance in the more recent studies relating to the liquefaction of gases. Illustrious and well-known scientists and engineers in the history

of the liquefaction of gases are herewith mentioned in association with the work of van der Waals as follows: Witkowski, Wroblewski, Olszewski, Onnes, Ramsay and Young, Travers, Clausius, Dieterici, MacDougall, Trouton, Linde, Hampson, and Claude.

In 1876 Linde[24] devised the earliest ammonia refrigerating machine wherein he employed the cycle: rapid evaporation, compression, condensation, and valve regulation back to evaporator. Undoubtedly this was the beginning of Linde's great career in the field on gas liquefaction.

First Liquid Oxygen

In 1877 Pictet,[25] in Switzerland, and Cailletet[26] in France, working independently, were the first to prepare liquid oxygen. Cailletet compressed oxygen, cooled it with water and refrigerated it to the temperature available by the evaporation of liquid sulphur dioxide at reduced pressure, and then caused the compressed, cooled, and refrigerated oxygen to expand suddenly. Pictet employed for the first time the so-called cascade system of refrigeration. He used liquid sulphur dioxide to boil under reduced pressure and atttained a temperature of —40° F. This cold gas was circulated countercurrently to dry carbon dioxide under a pressure of four to six atmospheres. This procedure resulted in the liquefaction of carbon dioxide. The liquid carbon dioxide was then boiled under reduced pressure to attain temperatures approximating —140° F. The cold gaseous carbon dioxide was circulated countercurrently to the highly compressed oxygen and liquid oxygen was obtained. This is the first instance of the successful use of the so-called cascade system. Cailletet prepared large quantities of liquid ethylene and commended it as one of the most valuable refrigerants. He employed it, boiling under reduced pressure, as a cooling agent when he liquefied methane and other gases. The temperature which he realized was approximately —195° F. Liquid oxygen was produced by the adiabatic expansion of the compressed water-cooled cascade refrigerated oxygen. Since Pictet's time any system of refrigeration which uses a number of liquids with successively lower boiling points, each of which is to precool the next gas to be liquified, is called the cascade system. This discovery was another epoch in the history of liquefaction of gases. These two investigators liquefied air, oxygen, nitrogen, hydrogen, nitrous oxide, carbon monoxide, methane, and acetylene. Caillettet was the first to introduce the idea of adiabatic expansion with the performance of external work.

In the period 1876 to 1893 Amagat[27] issued nine publications covering the compressibility of gases and liquids. He investigated the deviations from Boyle's and Charles' laws which the following gases show: hydrogen, nitrogen, oxygen, air, carbon monoxide, methane, ethylene, carbon dioxide, and amylene, and contributed largely to the determination of the values of constants a and b in the van de Waals equation of condition. The knowledge of these deviations is of primary importance in the problems of gas liquefaction.

In 1878 Windhausen[28] constructed an ice machine (in London, England) capable of producing 12 tons of ice per day. The refrigerating cycle which was employed, consisted of the absorption of vapor at a low temperature and its release at a higher temperature. The cost of operation was prohibitive commercially.

In 1879 Coleman[29] of Glasgow, Scotland, equipped two ocean-going vessels with refrigerating machines. These vessels were used for the transportation of food stuffs from America and Australia. The two installations were the first application of refrigeration to ocean transportation. The machine which Coleman built contained the first commercial heat exchanger, which he described as "an apparatus whereby the compressed gas (water-cooled) was further cooled before expansion by means of the cold air from the room in its passage (from the expansion chamber) to the compressor, the same air being used over and over."

In 1880 Linde[30] devised his machine in which liquid carbon dioxide was used as a refrigerant, and a cycle similar to that in his earlier ammonia machine was employed.

In the period 1883-4 Wroblewski[31] and Olszewski, working in the University of Cracow, Poland, liquefied oxygen, nitrogen, and carbon monoxide, and studied the physical properties of these liquids. The cascade system of refrigeration was employed using the liquids: sulphur dioxide, carbon dioxide, and ethylene. They realized a minimum temperature of —238° F.

Olszewski[32] was the first to study in a detailed and accurate manner all of the temperature, pressure, and volume relations of liquid methane.

Research by Kammerlingh-Onnes

In 1884 Kammerlingh - Onnes,[33] working in the University of Leiden, Holland, conducted probably the most extensive and successful researches ever attempted in the matter of liquefying gases. Numerous and various cascade systems were employed and all known gases were successfully liquefied in his laboratory. His greatest achievement was in 1908 when he liquefied helium,—the gas which had resisted all prior attempts at liquefaction. Onnes realized temperatures closely approximating the absolute zero. In the preparation of liquid helium highly compressed helium was circulated through an apparatus in which it was cooled first to the temperature of boiling liquid air, and then to —432° F. by means of liquid hydrogen boiling under 60 mm. pressure, and then it was passed through a specially constructed liquefier of the Hampson type. (See later reference). In 1908 Onnes continued his fundamental research on liquefaction of gases and his study of the many physical properties of these liquids. He employed the cascade principle wherein he used liquid methyl chloride, ethylene, oxygen, and nitrogen, on the one hand, and on the other hand, a cascade cycle composed of liquid ammonia, ethylene, methane, and nitrogen. In his low temperature work, Onnes used alloy electrical resistant thermometers made of constantan, phosphor bronze containing lead, and carbon.

Keesom,[34] a colleague of Onnes, used a cascade cycle of ammonia, ethylene, methane, and nitrogen in his work leading up to the solidification of helium. (June 26, 1926). Every known gas and liquid had been solidified. Based upon measurements which he made, the work required in the production of one gallon of liquid nitrogen was 2.05 kilowatt hours. This figure included all thermal and fractional losses which might be expected to occur in practice. Based upon the data used by Keesom, it has been calcu-

lated that one gallon of liquid methane at atmospheric pressure will require only 0.649 kilowatt hours.

In 1884-6 Dewar[35] prepared large quantities of liquid oxygen and air in a cascade system wherein methyl chloride and ethylene were used. He also constructed the first successful vacuum-walled containers for liquid gases. In securing the high vacua he used activated charcoal as absorbent of residual gases. Prior to the development of the vacuous container, various materials—metallic and non-metallic —covered with insulating materials were used to contain or store the liquid gases. It seems highly probable that Dewar was the first to make use of the so-called pentane thermometer.

In 1895 Hampson[36] realizing the commercial importance of air liquefaction, devised a so-called simple form of apparatus known as the Hampson liquefier. The regenerative system of cooling was employed commercially for the first time. Both Hampson and Linde sensed the commercial possibilities of the separation of liquid air into its various components and reasoned from their knowledge of the fractionation of alcohol and petroleum that this separation could be easily and commercially effected.

In 1895 Linde,[37] working independently of Hampson, devised the process which bears his name, for the production of liquid air, oxygen, and nitrogen. This process does not require the use of auxiliary refrigerants. It is the method of so-called self intensive refrigeration. Air is freed of its content of dust, water, and carbon dioxide. It is highly compressed and the heat of compression is rejected by water cooling. The double circulating type of regenerative cooling is employed and the cooling is that obtained by the Joule-Thomson effect. In 1897 he made the first technical application of liquid air to the manufacture of explosives.[38]

In 1898 Dewar[39] succeeded in liquefying hydrogen. He utilized the cascade principle of precooling the highly compressed hydrogen and then the Joule-Thomson effect with double regenerative cooling. He attained a minimum temperature of —432.4° F.

In 1899 Thrupp[40] devised apparatus and methods for the refrigeration of liquefied air and other gases. Auxiliary cooling was effected by ammonia and final cooling by an expander turbine doing external work. "The apparatus may be used for separating ethylene and other more easily condensible hydrocarbons from ordinary coal gas, or separating hydrogen from coal gas or water gas by liquefying the other constituents of the mixture." Regenerative cooling was employed and the liquefied gas holder or other receptacle as required was surrounded by an annular space and a thick enclosure or jacket of insulating material.

Continuous Liquefaction

In 1900-02 Claude[41] used the expansion engine wherein a portion of the highly compressed and water cooled gas was expanded in a cylinder fitted with a piston, thereby performing external work and lowering the temperature of the gas below its critical temperature. The cold expanded gas was utilized in cooling the portion of gas which was still under high pressure. The result of the procedure was the liquefaction of the gas in a continuous manner. Claude employed a peculiar type of heat exchanger: "This consists of wide baffle tubes in which the incoming gas is cooled and in some cases partially liquefied at the expense of the outgoing cold product, the latter passing through narrow vertical tubes within the exchanger." In the large scale plants employing the Claude process double expansion engines and dephlegmators are used.

In 1901 Dyer[42] invented an apparatus for carrying out a method of reducing the temperature of gases or vapors. Primary, secondary, and tertiary cooling devices were specified in a series. The gas from each device was expanded and used countercurrently and progressively in cooling the oncoming high pressure gas or vapor.

In 1910 Erdmann and Stolzenberg[43] experimented with liquid air in the analysis of gases by fractionation at temperatures thus available. Some use was made of the published data regarding liquefaction and solidification temperatures and pressures.

In 1910 Peterson, Kerr, Phinney, and Snelling[44] investigated the possibilities of commercially liquefying natural gas and later built a plant at Follansbee, West Va., for the commercial exploitation of the so-called "Gasol." Natural gas as it came from the well or line was compressed to 35 atmospheres and cooled to ordinary temperature with water. A liquid was obtained and was composed largely of liquid ethane and propane. Some methane was in solution. One volume of the liquid when vaporized yielded 350 volumes of gas under standard conditions of temperature and pressure. This material was sold extensively in steel cylinders under pressure.

In 1911 Heylandt[45] was the first to use a turbine for the production of liquid air. His patents[46] covered the use of an expansion engine for cooling in such a way as to avoid the use of ordinary lubricants. He used two mixtures for producing low temperatures in the liquefaction of gases, namely, 1) snow and salt, and 2) solid carbon dioxide and diethyl ether. Certain patents of Heylandt[47] covered well insulated metallic containers for the storage and transportation of liquid gases, such as liquid air, liquid oxygen, liquid hydrogen, etc.

A patent entitled *Process for the Production and Maintenance of a High Vacuum, Especially in Metal Vessels for the Storage and Transportation of Liquefied Gases*[48] covered an improvement of the procedure of Dewar.[49] The activated carbon as used by Dewar was replaced by magnesium carbonate or magnesium oxide. Heylandt claimed higher adsorptive qualities for these substances than that of activated charcoal. It is stated in the literature that large conainers for the storage and transportation of liquid gases have been built wherein these substances have been used.

In 1912 Burrell and Allen[50] minutely described liquefied products from natural gas, their properties and uses.

In 1913 Lebeau and Damiens[51] devised a method of analysis for complex mixtures of hydrogen and gaseous hydrocarbons by fractional distillation at low temperatures. This work was one of the forerunners of the classical and highly important work of Col. G. A. Burrell and his associates in the Bureau of Mines, and the more recent work of Podbielniak.

In 1913 Burrell and Seibert[52] published a technical paper entitled *Errors in Gas Analyses Due to Assuming that the Molecular Volumes of All Gases Are Alike.* This publication had fundamentally to do with the van der Waals equation of condition and Haber's work entitled *Thermodynamics of Technical Gas Reactions.*

In 1914 Cabot[53] made applications for letters patent entitled *Means for Storing and Transporting Liquid Gas* and *Apparatus for Condensing Gas Under High*

Pressure. Specifically these applications covered apparatus and processes for the liquefaction of natural gas, its storage, its transportation in large quantities in barges, and its vaporization at destination, such as desired when such gas is necessary for lighting, heating, and propulsion purposes. Novel features of construction, combination, and arrangement of parts were claimed.

In 1915 Burrell, Seibert and Robertson[54] published a technical paper entitled *Analyses of Natural Gas and Illuminating Gas by Fractional Distillation at Low Temperatures and Pressures.* In conducting the research the investigators prepared pure methane, ethylene, propane, butane, butylene, carbon dioxide, and acetylene. The authors state: "there are scarcely any gases that cannot be purified by careful adjusting and using the proper temperature so that they are pure enough for the finest density of vapor-pressure work." Many samples of natural and manufactured gas were analyzed. Fundamental to this work was the then

PATENT SITUATION

The following list of patents and references cover the various methods of storing and transportation of liquefied gases prior to 1919, and are of noteworthy value relative to the pending plans for the storage and transportation of liquefied natural gas:

1) W. Ann. der Phys. 66, p. 544 (1898)
2) d'Arsonval, Compt. Rend., 126, 1686 (1897)
3) Dewar, Weidemann's Beibl., 18, 334 (1894); 20, 193 (1986); German Patent No. 169,514
4) Stock, German Patent No. 189,832; Austrian Patent No. 34,524; French Patent No. 384,789
5) Thermos, A. G., German Patent No. 212,670; 221,270
6) Winand, German Patent No. 197,713
7) Beckman, Zeit. fur angewandte Chemie, 22, 673
8) Claude, Air Liquide, Oxygen, Azote 1909 p. 258
9) Place, U. S. Pat. 646,459; 707,634 883,479; Brit. Pat. 5976/1900; French Pat. 321,860.
10) Jolys, British Patent No. 14,673/1900; 11,835/1899; 21,816/1899.
11) Chase, U. S. Pat. No. 652,471; 911,294
12) Heylandt, German Pat. No. 165,682; French Pat. No. 343,818; British Pat. No. 17,884/1905; U. S. Pat. No. 797,577
13) Schumann, Austrian Pat. No. 42,029
14) Ostergren, German Pat. No. 115,772; Austrian Pat. No. 4,426 British Pat. No. 10,883/1899; U. S. Pat. 644,259
15) Brady, U. S. Pat. No. 662,217; British Pat. No. 6039/1899; Austrian Pat. 1704
16) Sewall, U. S. Pat. No. 665,349
17) Bobrick, U. S. Pat. 673,073
18) Hargrave, U. S. 625,760; British Pat. No. 11,243/1899
19) Groth, British Pat. No. 13,588/1908
20) Societe L'Air Liquide in Paris, French Pat. No. 337,127
21) Erlwein and Marquardt, German Pat. No. 188,899; Brit. Pat. 24,673/1906
22) Monasch, German Pat. 209,665
23) Beck, German Pat. No. 182,405
24) Kowastch, German Pat. 294,611; 305,740
25) Sieder, German Pat. No. 297,000
26) Ockelmann, German Pat. No. 192,013
27) Bock and Russbacher, German Pat. 225,462
28) Heylandt-Gesellschaft, German Pat. 250,263; Austrian Pat. No. 54,105; U. S. Pat. 1,033,398; Brit. Pat. No. 1663/1912
29) Gesellschaft fur Linde's Eismaschinen A. G., German Pat. 295,141
30) Mewes, German Patent Nos. 259,825; 292,727; 311,353
31) Fate, German Pat. 246,623
32) Hinkel, German Pat. 295,752; 306,031.
33) Gehlig, German Pat. No. 296,006
34) Lilienfeld, German Pat. 253,975; 253,976
35) Koniglichen Porzellen Manufaktur, German Pat. No. 305,330; 305,982
36) Kiel, German Pat. No. 305,570; 289,161
37) Smoluchowsky, German Pat. No. 268,490
38) Porzellanfabrik Akt. Ges., German Pat. No. 308,772
39) Sprengluft-Gesellschaft, German Pat. 310,592

In the above list of patents and references the following are noteworthy: 1) Double-walled containers—inner and outer vessels concentrically placed, either cylindrical or spherical, with provisions for eliminating or reducing to a minimum heat transmission to the contents of the inner vessel, and provisions are made for evacuating the space between the walls; 2) The materials used in the construction of the walls of the two vessels are: of glass, porcelain, metallic alloys, tin plate, manganese steel, lead, and copper. Textile fabrics, cardboard, hard rubber, papier-mache, and similar materials are coated inside and outside with resins made of formaldehyde and phenol and used as insulating materials. (German Pat. No. 259,825); 3) The various insulating materials specified are: asbestos, cork, feathers, porous or perforated materials, paper, wood fibre or pulp, wood, wool felt, hair felt, mineral or slag wool, glass wool, clay, ebonite, papiere mache, blotting paper, various thin metallic sheets, lycopodium or club moss, diatomaceous earth, lamp black or soot, zinc powder, emery, quartz powder, coke powder or dust, silk, and other textile fabrics; 4) The evacuated space betwen the walls is produced mechanically and/or by the addition of substances like activated charcoal, magnesium carbonte, magnesium oxide, porous carbon pressed in blocks like cork, to absorb residual gases; 5) Air contained in the inner space is replaced with the vapors of sulphur dioxide or carbon disulphide and use made of the peculiar properties of these substances in producing the vacuous space; 6) Provision is made for the reduction of radiant heat by use of mirriors on the faces of the surfaces containing the low pressure gases: These mirrors are: of mercury, silver, and various highly polished surfaces; 7) Containers for use in express and rail shipments have been provided; 8) Containers for transportation of rather large capacity (3170 gallons) are described for shipments by truck or rail.

Patents Relating to the Liquefaction of Gases

(All U. S. Patents)

TITLE	Inventor	Granted	Patent Number	Date Application
Cooling and separating a lubricating agent from a compressed gas, and liquefaction of gases and production of refrigeration	J. J. Suckert	6-16-85	320,305	4-24-85
Process of liquefying gases and producing refrigeration	J. J. Suckert	6-16-85	320,306	4-28-85
Method of and apparatus for purifying and liquefying gases and producing refrigeration	J. J. Suckert	6-19-85	320,307	4-24-85
Process of separating and cooling a sealing or lubricating liquid in apparatus for producing refrigeration	J. J. Suckert	6-16-85	320,308	4-28-85
Separating and cooling a sealing or lubricating liquid in producing refrigeration	J. J. Suckert	6-16-85	320,309	5-18-85
Method of and apparatus for separating a liquefiable gas from a condensable vapor	J. J. Suckert	6-16-85	320,310	3-25-85
Process of and apparatus for making liquid chlorin	R. Knietsch	10-10-93	506,639	6- 5-90
Package of liquid chlorine	R. Knietsch	10-10-93	506,640	9-12-92
Apparatus for separating mixed gases by refrigeration, especially applicable to separating oxygen from air	Wm. Hampson	2-29-99	620,312	10-10-96
Apparatus for liquefying air	Ostergren and Bruger	3-21-99	621,536	8-11-97
Apparatus for liquefying gas	Ostergren and Burger	3-21-99	621,537	10-13-98
Apparatus for separating and recovering valuable vapors	J. R. Whiting	4-11-99	622,036	1-10-98
Process of producing and liquefying acetylene gas	Dickerson and Suckert	5-25-99	629,669	12- 6-97
Apparatus for refrigerating and liquefying air or other gases[1]	E. C. Thrupp	1-30-00	642,505	2-28-99
Portable vessel or bottle for holding and shipping liquid air or other liquid gases	J. F. Place	4- 3-00	646,459	12-18-99
Liquifier for atmospheric air	C. E. Tripler	6-19-00	652,058	2- 7-00
Process of separating oxygen and nitrogen from mixtures thereof	R. P. Pictet	10- 1-01	683,492	8- 5-99
Method of reducing the temperature of gases or vapors	F. L. Dyer	10-14-02	710,957	3- 3-99
Apparatus for reducing the temperature of gases or vapors	F. L. Dyer	10-14-02	711,419	3- 3-99
Process of producing low temperatures, the liquefaction of gases, and the separation of the constituents of gaseous mixtures	Carl Linde	5-12-03	727,650	7- 9-95
Mechanism for separating liquid air into its constituents, oxygen and nitrogen	Horace Dumars	1- 5-04	749,040	12-19-02
Apparatus for producing pure nitrogen and pure oxygen	Carl Linde	7-25-05	795,525	10-22-03
Storage vessel for liquefied gases	Heylandt	8-22-05	797,577	4-30-04
Apparatus for the separation of gases from their mixtures	R. P. Pictet	1- 2-06	809,218	5-24-01
Apparatus for liquefying gas and separating its elements	Carl Linde	3-20-06	815,544	11- 7-02
Apparatus for producing pure nitrogen	Carl Linde	3-20-06	815,601	10-22-03
Refrigerating apparatus	Frank Rider	6- 4-07	855,983	11-10-06
Insulated container for liquid air, etc.	J. F. Place	3-31-08	883,479	4-28-05
Process for the liquefaction of gases, and separation of air into commercial oxygen and nitrogen	G. A. Bobrick	6- 8-09	924,136	5-16-04
Process of separating oxygen from air	Claude	6- 8-09	924,428	8- 5-03
Air liquefier	J. F. Place	7-13-09	927,594	9-11-06
Process for the separation of oxygen and nitrogen from liquid air	Claude	2-22-10	950,436	12-31-03
Separation of gases from their mixtures	Levy and Hellbronner	5- 3-10	759,170	6- 3-07
Method for the separation of gases, etc.	Levy and Hellbronner	5-31-10	959,563	2-16-03
Process for cooling and liquefying gases	Hildebrandt	6-29-10	962,836	12- 4-07
Refrigerating or cooling apparatus	Hildebrandt	7- 5-10	963,555	12-20-07
Process for the separation of gaseous mixtures in their elements	Claude and Levy	8- 9-10	967,105	6- 3-04
Process of liquefying air and separating out oxygen	Mewes	1- 3-11	980,813	3- 2-06
Liquefaction of air and its separation into its constituents	Claude	1-17-11	981,748	6- 1-09
Process of liquefying air and separating it into its elements	Janecke	1-30-12	1,015,800	10-27-09
Process for the production of hydrogen from gas mixtures containing hydrogen[2]	Linde	3-12-12	1,020,102	10-10-10
Method of extracting rare gases from the air	Claude	5-14-12	1,025,962	9-22-09
Apparatus for the separation of hydrogen from a gaseous mixture	Linde	5-28-12	1,027,862	10-10-10
Metallic vessel for liquefied gases	Heylandt	7-23-12	1,033,398	2- 6-12
Process for the separation of the constituents of gaseous mixtures	Claude	7-22-13	1,068,219	2-10-11
Apparatus for liquefying gaseous mixtures	Blau	9-23-13	1,074,094	7-31-11
Process of producing ozone and separating gases	Dumars	9-30-13	1,074,106	2-28-12
Process of separation of the constituents of gaseous mixtures	Claude	1-13-14	1,083,988	3-17-10
Process of separating liquid air into its constituents	Hildebrandt	12- 1-14	1,119,158	10-16-12
Apparatus for separating liquid air into its constituents	Hildebrandt	12- 1-14	1,119,159	10-16-12
Process of separating gaseous mixtures into their constituents	Pictet	12- 1-14	1,119,312	6-27-13
Means for handling and transporting liquid gas	Cabot	5-18-15	1,140,250	10-12-14
Apparatus for obtaining liquid hydrocarbons	Maag	6- 8-15	1,142,525	6-11-14
Air liquefier and separator	Place	7-13-15	1,146,020	1- 2-08
Apparatus for producing ozone and separating gases	Dumars	8-10-15	1,149,254	2-28-12
Apparatus for recovering hydrocarbon products from gas	Roberts	8-17-15	1,150,454	2-25-11
Art or process of liquefying and separating air	Place	8-31-15	1,152,044	11-29-07
Art or process of liquefying air and separating it into oxygen and nitrogen	Place	8-31-15	1,152,120	11- 9-11
Art or process of liquefying air and separating the same into oxygen and nitrogen	Place	10-26-15	1,157,959	11-13-11
Method of separating gas mixtures[3]	Lillienfeld	12- 7-15	1,163,423	10-13-11
Apparatus for separating vaporized volatile liquids from gaseous mixtures[4]	Lummus	7- 4-16	1,189,711	3-18-12
Apparatus for liquefying gases with a low boiling point[5]	Hildebrandt	9-26-16	1,199,700	1- 9-11
Apparatus for dividing air into its elements by fractional distillation	Flamend	10-10-16	1,201,043	12- 9-08
Art or method of producing oxygen and nitrogen	Flamend	10-10-16	1,201,044	12- 9-08
Art or process of separating the gases of air	Place	11-21- 1	1,205,477	6- 8-15
Apparatus for the separation of the constituents of air	Place	11-21-16	1,205,478	6- 9-15
Apparatus and process for concentrating argon	Fonda	1- 2-17	1,211,125	10-12-15
Apparatus for liquefying and separating gases	Mewes	2-13-17	1,215,957	10- 7-15
Course-finder	Sisters	5- 8-17	1,225,514	9-27-16
Apparatus for condensing gas under high pressure	Cabot	5- 8-17	1,225,574	10-26-14
Apparatus for the liquefaction and rectification of air[6]	Filippo and Schoonenberg	2-26-18	1,257,470	6- 3-16
Apparatus for liquefying air and separating it into its constituents	Crommett	11- 5-18	1,283,472	6-30-15
Apparatus for liquefying air	Place	1- 6-20	1,326,961	2-14-16
Apparatus for the separation of mixed gases[7]	Norton	9-28-20	1,354,059	10-10-15
Apparatus for filling oxygen cylinders	von Reckling-hausen	10-25-21	1,394,955	2-23-17
Regulating means for gas-separating apparatus	Barbet	11- 1-21	1,395,466	6-25-19
Refrigerating apparatus[8]	Norton	5-30-22	1,418,015	3- 3-15
Apparatus for the separation of gaseous mixtures	Haynes	9-19-22	1,429,903	4-12-19
Apparatus for the rectification of air	Davis	10-23-23	1,471,833	7- 7-20
Apparatus for liquefying and separating gas mixtures[9]	Mewes	10- 7-24	1,510,793	3-30-21
Process for the separation and purification of Argon and other rare gases in the atmosphere	Barbet	10-21-24	1,512,268	7- 8-19
Apparatus for the production of oxygen and nitrogen	Lafferty	10-28-24	1,513,116	3-22-19
Refrigeration and power system	Bowen, et al	12-16-24	1,519,353	8-31-20
Liquefaction of gases	Van Nuys	12-30-24	1,521,138	3-19-21
Metal vessel for storing and conveying liquefied gases	Heylandt	1-13-25	1,522,886	1- 3-21
Apparatus and process for fractionating air	Fonda	9-20-18	1,527,639	9-20-18
Method of separating the constituents of gaseous mixtures	Van Nuys	5-26-25	1,529,538	9- 9-20
Method and apparatus for avoiding shock chill in precipitating substances from liquids	Jones	10-27-25	1,558,619	2- 5-21
Process of recovering helium	Rafferty, et al	3-10-25	1,529,625	6-15-23
Separation of the constitutents of gaseous mixtures	Van Nuys	10-20-25	1,557,907	5-24-23
Liquid-oxygen container	Mott, et al	11-10-25	1,561,101	1-28-24
Liquefaction of gases	Recordon	11-24-25	1,562,915	6-24-22
Method for low-temperature cooling, liquefaction, and separation of not easily condensable gases	Seligman	2-16-26	1,573,752	3- 3-24
Vacuum bottle	Anthon	6-15-26	1,589,088	3- 5-21
Process for separating gas mixtures, more especially air or other difficultly liquefiable gas mixtures	Mewes, et al	7-27-26	1,594,336	3-12-24
Liquid-oxygen container	C. Mott	8-31-26	1,598,149	5-22-24
Liquefaction apparatus	Schlitt, et al	10-26-26	1,604,240	2- 5-26
Apparatus for the liquefaction and separation of the constituents of gaseous mixtures	Van Nuys	10-26-26	1,604,248	9- 9-20
Apparatus for liquefaction and rectification of gases	Van Nuys	10-26-26	1,604,249	12- 2-19
Liquefaction and separation of gaseous mixtures	Van Nuys	11-16-26	1,607,321	1-31-23
Method for low temperature cooling, liquefaction and separation of gases	Seligmann	1-25-27	1,615,597	3- 3-24
Separation of the constituents of ternary gaseous mixtures	Wilkinson	3- 8-27	1,619,909	10-15-25
Liquefaction of air and separation into nitrogen and oxygen	Leuning	6-28-27	1,634,076	6-28-27
Process of separation of the elements of air or of other gaseous mixtures by liquefaction and rectification	LeRouge	8- 2-27	1,638,005	7-21-22
Production of helium from natural gas	Haynes	4- 3-28	1,664,412	8- 7-19
Liquefaction apparatus	Tolman	7- 3-28	1,676,225	9-16-22
A method of separation and liquefaction of gases	Bowen	12- 4-28	1,694,308	1-11-27
Oil-recovery and gasoline extraction apparatus	Dunn et al	7-16-29	1,721,010	8- 2-26
Method and device for the regasification of liquefied gases	Heylandt	2-18-30	1,747,366	2-16-28
Method of preparing compressed gases	Heylandt	8-19-30	1,773,140	8-24-28
Method of and apparatus for liquefying gases	Strong	11- 4-30	1,780,250	3-27-30
Container for storage and transport of liquefied gases	Braunstein	11-11-30	1,781,048	2-16-29
Method and device for producing compressed gas from liquefied gas	Heylandt	7- 7-31	1,812,954	1- 3-30
Container for compressed or liquefied gas	Wulff, et al	6-21-32	1,863,958	2-24-29

Patents Relating to the Liquefaction of Gases—Continued

(All U. S. Patents)

TITLE	Inventor	Granted	Patent Number	Date Application
Apparatus for preparing pressure gases	Heylandt	5- 5-32	1,866,514	10- 5-27
Apparatus for conserving and vaporizing liquefied gases	Picard	9-20-32	1,878,317	9-29-29
Apparatus for the distribution of gases under pressure by means of liquefied gases	Picard	1-24-33	1,895,295	12-18-28
Apparatus for transferring and storing liquefied gases	Heylandt	3-14-33	1,901,445	11-12-27
Method of conserving liquefied gases	Heylandt	3-14-33	1,901,446	11-21-27
Apparatus for preparing pressure gases	Heylandt	3-14-33	1,901,447	10- 5-27
Container for liquefied gases	Heylandt	7-18-33	1,918,335	11-21-27
System for producing and storing liquid oxygen	Kinson	11-21-33	1,936,059	1- 5-33
Apparatus for and method of producing compressed gas	Levin	8- 8-33	1,921,531	2- 3-32
Liquid oxygen apparatus	Hickling	12-12-33	1,939,592	4-20-31
Container for liquefied gases	Dana and Zenner	10- 9-34	1,976,688	4-19-32
Container for liquefied gases	Dana	10-30-34	1,979,221	1-19-33
Container for liquefied gases	Hansen, et al	10-30-34	1,979,224	1-19-33
Process and apparatus for dispensing measured charges of liquefied gas	Harvey	11-20-34	1,981,729	12-30-33
Process of and apparatus for transferring liquefied gases	Legarde	4-23-35	1,998,629	4- 7-32
Transfer of liquefied gases	Salnikoff	5-14-35	2,001,253	4- 5-33
Apparatus for handling liquefied gases	Thomas, et al	8-27-35	2,012,561	9-25-31
Pump for compressed liquefied gases	Teers	1-21-36	2,028,531	7-31-33
Method and apparatus for dispensing gas material	Mesinger	3-24-36	2,035,296	3- 1-35
Cascade system and method of operating same	Murphy	3-24-36	2,035,399	11-14-34
Method and apparatus for effecting the discharge of a volatile liquid	Zenner	4-14-36	2,037,673	1-24-35
Method and apparatus for rejecting heat from a cascade system	Dana	4-14-36	2,037,679	1-24-35
Method and apparatus for operating cascade systems with regeneration	Gaines, Jr.	4-21-36	2,037,714	3-13-35
Art of refrigeration	Podbielniak	5-26-36	2,041,725	7-14-34
Warm converter for liquefied gases of low boiling point	Dana	8-16-36	2,044,670	3-20-34
Method of liquefying and storing fuel gases	Twomey	6- 1-37	2,082,189	5- 9-34
Method of liquefying and storing fuel gases	Twomey	8-17-37	2,090,163	5- 9-34
Construction for double-walled tank cars[10]	Hansen	1-21-41	2,229,079	8-19-39
Double-walled container for tank cars	Zenner, et al	1-21-41	2,229,080	8-19-39
Double-walled vaccum insulated tank car	Hansen, et al	1-21-41	2,229,081	8-19-39
Double-walled insulated tank car construction	Van Vleet	1-21-41	2,229,082	8-19-39

[1] Expander turbine doing work; insulated vessels; regenerative cooling. Apparatus C_2H_4 or other hydrocarbons from coal or water gas. [2] Illuminating (water) gas—liquefaction of other constituents internal and external work. [3] Progressive expansion and cooling. [4] Expansion in stages. [5] Travers "velocity cooling". Air and hydrogen. [6] Norton, U.S. Pat. 1,264,845, 4-30-18. [7] Water gas liquefaction and separation. [8] See also U.S. patent 1,264,845, 4-30-18. [9] Water gas. [10] Vessel.

known and accurately determined physical constants of methane, ethane, ethylene, propylene, isobutane, isobutylene, nitrogen, oxygen, carbon monoxide, and hydrogen.

In 1916 Burrell and Robertson[55] described methods, apparatus, and results of experiments on the compressibility of natural gas at high pressures.

Production of Helium

In 1917 Burrell, Moore, Cottrell, and Seibel[56] began the investigation of the possibilities of producing helium. Cady and McFarland had discovered the existence of helium in natural gas. The prior scientific work, as given herein, provided accurate and dependable data regarding the physical constants of all of the constituents of natural gas. These data were used in making the plans for the experimental plants at Petrolia and Fort Worth, Texas. The problems involved in the separation of helium from the other components of natural gas were similar in character to those involved in the liquefaction of air and its separation into its components. The cooperation of Linde Air Products Company, Air Reduction Company, and Jeffries-Norton Corporation was solicited and obtained. A plant was built to test out the possibilities of the processes of each of the three cooperating companies. The operation of the experimental plants was sufficiently successful to warrant the U. S. government in building a larger scale plant near Fort Worth. This plant continued in operation until January 10, 1929, when it was discontinued by reason of the approaching exhaustion of the Petrolia gas field. In July, 1928, plans were formulated for the building of the large helium production plant at Amarillo, Texas.[57] In this plant natural gas containing about 2 percent helium, 0.7 percent carbon dioxide, together with the hydrocarbons normally present in most supplies of natural gas, was treated for the recovery of helium. The natural gas was delivered to the plant at a pressure of somewhat more than 650 pounds and thus did not require further compression. The carbon dioxide content was removed by scrubbing with a 6 percent solution of caustic soda. The water vapor was removed from the gas by cooling in a heat exchanger by means of the spent gas on its road as needed in Amarillo—seven miles distant—and under a pressure of 75 pounds. Practically all the gas entering the plant at ordinary room temperature was cooled to —300° F., and brought back to room temperature for delivery to Amarillo. The initial refrigeration, and that necessary to make up for some of the heat losses, is produced in a separate cycle, wherein nitrogen was used. This was compressed to 500 pounds per square inch then cooled with water and expanded through a small expansion engine to atmospheric pressure and returned through heat exchangers to the gas holder. The expansion engine was caused to do work by running an electric generator. The system was cooled progressively in this manner until the exhaust of the engine was sufficiently cold for the purpose. Considerable cooling was obtained by throttling the natural gas from 650 pounds to the return gas pressure of about 75 pounds. Not much refrigeration was needed from the expansion engine after the plant had reached a steady operating condition. In this plant all of the hydrocarbons of natural gas were liquefied, the helium and nitrogen remained as gases. The separation was easily effected. The liquefied natural gas was revaporized, brought up to ordinary room temperature, and delivered into the Amarillo line at 75 pounds pressure where it was sold to the gas company as needed for domestic and industrial consumption.

In 1929 a book entitled *Geschichte der Gesellschaft fur Linde's Eismachinen A. G. Weisbaden* was published. Reference is particularly made herein to pages 131-133, 154 and 155. Coke oven gas of the following variable composition was used in order to prepare gaseous hydrogen for use in the synthesis of ammonia:

Methane	22 to 25 percent
Ethylene	1 to 2 percent
Higher hydrocarbons	3 to 4 percent
Hydrogen	50 to 57 percent
Carbon monoxide	5 to 7 percent
Carbon dioxide	2 to 5 percent
Nitrogen	6 to 12 percent

After preliminary treatment of the coke oven gas in a tower for the removal of sulphur compounds and a major portion of the carbon dioxide, the gas is compressed by two or three stage compression, to a

English, German and French patents relating to the liquefaction of gases, including the manufacture of oxygen, nitrogen and hydrogen from liquefied gases are as follows:

INVENTOR	Patent Number	Date
English Patents		
Aumont	11,306	1911
Bobrick	25,829	1908
Claude (also Soc. L'Air Liquide)	12,905	1900
Claude, etc. as above	28,682	1903
Claude, etc.	26,435	1905
Claude, etc.	27,658	1902
Claude, etc.	29,733	1906
Claude, etc.	12,358	1904
Claude, etc.	17,216	1909
Claude, etc.	7,305	1910
Claude, etc.	16,298	1903
Claude, etc.	20,349	1907
Claude, etc.	7,175	1910
Claude, etc.	3,302	1907
Claude, etc.	3,326	1911
Claude, etc.	22,316	1909
Claude, etc.	11,710	1907
Claude, etc.	5,395	1909
Gases	18,386	1911
Code and Knudsen	19,838	1901
Dumars	11,126	1903
Flussige Luft Heylandt	16,615	1909
Goldschmidt	12,743	1908
Hempson	10,165	1895
Hempson	7,559	1896
Hempson	7,773	1898
Hazard and Flamand	26,720	1908
Hazard and Flamand	27,592	1908
Hers	21,191	1901
Hildebrandt	11,212	1905
Hildebrandt	13,790	1907
Hildebrandt	25,517	1907
Hildebrandt	6,515	1909
Hildebrandt	13,034	1907
Hildebrandt	26,186	1907
Hildebrandt	3,316	1910
Hildebrandt	15,999	1910
Hildebrandt	19,336	1910
Hildebrandt	1,828	1907
Janecke	23,107	1909
Joly	21,861	1899
Joly	12,918	1901
Joly	15,511	1901
Knudsen	23,646	1902
Knudsen	6,087	1903
Knudsen	19,033	1906
Lake	11,609	1902
Leptien	2,497	1910
Leslie	11,902	1906
Levy	16,615	1902
Levy	3,649	1903
Levy and Hellbronner	20,053	1902
Linde (also Ges. fur Linde Eismach.)	12,528	1895
Linde, etc. as above	14,111	1902
Linde, etc.	11,221	1903
Linde, etc.	7,205	1911
Linde, etc.	9,260	1911
Lilienfeld	22,930	1911
Loumet	17,605	1902
Marks	25,829	1908
Merves	24,144	1905
Merves	21,780	1906
Ostergren and Burger	26,361	1898
Parkinson	4,411	1892
Pictet	14,303	1903
Pictet	2,713	1901
Pictet	19,254	1900
Pictet	21,120	1902
Pictet	14,431	1904
Pictet	27,463	1910
Place	11,609	1902
Place	13,529	1907
Place	3,685	1908
Ramsey	26,981	1907
Roetiger	7,858	1910
Schneider	2,496	1910
Schneider	11,461	1910
Schmidt	13,304	1909
Schmidt	6,515	1909
Siemens	2,064	1857
Strong	9,142	1900
Sueur	10,722	1900
Sueur	4,828	1901
Thrupp	26,767	1898
Thrupp	1,913	1900
Tofehrn	21,085	1898
Tripler	15,235	1899
Wiart	26,052	1907
German Patents (Dates Not Available)		
Blau	223,843	....
Chemische Fabrik Greisheim-Blektron	240,876	....
Claude (also Soc. l'Air Liquide)	173,276	....
Claude etc. as above	177,519	....
Claude, etc.	179,950	....
Claude, etc.	192,594	....
Claude, etc.	193,008	....
Claude, etc.	202,778	....
Claude, etc.	234,308	....
Claude, etc.	235,422	....
Claude, etc.	237,438	....
Dragerwerk	179,793	....
Flussige Luft Heylandt	191,659	....
Hecker	204,807	....
Hildebrandt	169,331	....
Hildebrandt	179,132	....
Hildebrandt	181,115	....
Hildebrandt	183,410	....
Hildebrandt	193,007	....
Hildebrandt	197,071	....
Hildebrandt	198,503	....
Hildebrandt	214,264	....
Hildebrandt	223,064	....
Hildebrandt	228,487	....
Hildebrandt	229,345	....
Hildebrandt	247,581	....
Hildebrandt	249,006	....
Janecke	220,270	....
Janecke	246,341	....
Lachmann	167,931	....
Levy	191,916	....
Levi Cases	243,031	....
Levi and Hellbronner	158,838	....
Linde (also Ges. fur Linde Eismachinen)	88,824	....
Linde, etc. as above	173,260	....
Linde, etc.	180,014	....
Metz	119,943	....
Merves	174,362	....
Merves	179,782	....
Merves	195,754	....
Merves	199,035	....
Merves	209,074	....
Merves	209,848	....
Merves	222,840	....
Merves	227,100	....
Merves	229,276	....
Merves	230,002	....
Merves	233,897	....
Merves	238,690	....
Merves	242,867	....
Merves	249,997	....
Merves	251,584	....
Mix	124,376	....
Mix	142,918	....
Pictet	162,323	....
Pictet	162,702	....
Pictet	165,268	....
Pictet	159,934	....
Pictet	164,382	....
Pictet	169,359	....
Pictet	178,246	....
Pictet	169,564	....
Pictet	200,053	....
Solvay	39,280	....
Thrupp	115,421	....
Thrupp	142,935	....
Tripler	135,728	....
French Patents (Dates Not Available)		
Aumont	427,266	....
Bobrick	399,416	....
Claude (also Soc. l'Air Liquide)	296,211	....
Claude, etc. as above	299,051	....
Claude, etc.	328,245	....
Claude, etc.	352,856	....
Claude, etc.	322,107	....
Claude, etc.	324,097	....
Claude, etc.	370,850	....
Claude, etc.	381,790	....
Claude, etc.	338,842	....
Claude, etc.	416,556	....
Claude, etc.	401,496	....
Claude, etc.	410,967	....
Claude, etc.	322,702	....
Claude, etc.	324,460	....
Claude, etc.	329,939	....
Claude, etc.	338,964	....
Claude, etc.	423,224	....
Claude, etc.	376,270	....
Claude, etc.	381,866	....
Dumars	332,662	....
Hellbronner	376,176	....
Hildebrandt	355,206	....
Hildebrandt	373,894	....
Hildebrandt	384,139	....
Hildebrandt	403,630	....
Hildebrandt	420,903	....
Hildebrandt	417,537	....
Janecke	407,852	....
Joly	318,153	....
Levy	328,770	....
Levy	330,258	....
Levi Cases	433,639	....
Levi and Hellbronner	328,984	....
Linde (also Gesell fur Linde Eismachine)	312,811	....
Linde, etc. as above	322,811	....
Linde, etc.	333,205	....
Merves	360,427	....
Merves	358,236	....
Merves	425,546	....
Merves	426,908	....
Pictet	322,600	....
Pictet	295,002	....
Pictet	324,715	....
Pictet	409,787	....
Place	321,860	....
Place	379,605	....
Place	391,326	....
Roettger	413,958	....
Schneider	416,122	....
Thrupp	307,941	....

pressure of about twelve atmospheres. The residual carbon dioxide of about 0.3 percent is removed by scrubbing with sodium hydroxide solution. The cleaned and purified gas is then passed into an intercooler wherein, countercurrent to the gas stream, anhydrous ammonia is used as a refrigerant. This procedure cools the gas to a temperature of —40° F. to 58° F. Water and benzene vapors are condensed and removed. The cool gas then passes through another cooler countercurrent to liquid nitrogen as a refrigerant. All of the hydrocarbon content of the gas is liquefied. These hydrocarbons include methane, ethane, ethylene, propane, propylene, butane, and the butylenes. The non-condensed gaseous portion is made up largely of hydrogen and nitrogen. There is some carbon monoxide. The cooled gas under pressure is finally passed into a scrubber with more liquid nitrogen to purify it. The whole procedure involves known thermodynamic data. It is possible by means of this general process to liquefy the hydrocarbon content of any gaseous mixture.

In 1935 de Haas and Wiersma[58] attained a temperature of 0.003° absolute. They used a bath of liquid helium boiling at reduced pressure and based the temperature measurements upon the magnetic behavior of certain substances like gadolinium sulphate, iron ammonium alum, and potassium chrome alum.

Conclusion

The above review, arranged in chronological order, of the scientific, engineering, and patent facts, will disclose that the whole art of liquefying natural gas, whose chief constituents are hydrocarbons, is well known. All the necessary thermodynamic and engineering data are available for the calculation of any kind of a cycle which might be used. The principles herein utilizable are: 1) gas purification to remove water vapor, carbon dioxide, sulphur compounds, etc.; 2) three methods of refrigeration to realize the

necessary temperature of liquefaction: (a) Cascade system; (b) Joule-Thomson effect; (c) Expansion of high pressure gas through single or multistage engines or turbines doing external work; or (d) combinations of any of the three systems; 3) regenerative cooling; and 4) vaporization, or the conversion of the liquid into gas at any desired temperature and pressure.

Commercial Aspects

The commercial aspects of the liquefied gas business require consideration at this time. For many years past the following gases have been prepared commercially and shipped in inter-state commerce commission shipments as compressed gases in cylinders: helium, hydrogen, oxygen, nitrogen, and methane. Chlorine, ethane, propane, butane, isobutane, ethylene, propylene, ammonia, hydrogen sulphide, methyl chloride, nitrous oxide, sulphur dioxide, and carbon dioxide have been shipped in inter-state commerce commission shipments as liquids in steel cylinders. In the decade 1920-30 tank wagon and tank car shipments in inter-state commerce commission were made of chlorine, propane, butane, isobutane, ammonia, and sulphur dioxide. Shipments of liquefied petroleum gases have been made both by river barges and ocean tankers, and in one instance by long distance pipe lines. All of these methods of shipment were in vogue and practiced to a greater or less extent, depending on the demand for the gases prior to 1932, and has since undergone rapid expansion.

Since 1940, liquid oxygen has been produced and transported in tank wagons and tank cars.

The following statistical data relative to several of the liquefied gases show the magnitude of the industry:

LIQUEFIED GASES	Year	Amount Produced	Reference
Anhydrous ammonia	1945	548,655 short tons	59
Chlorine	1945	1,192,081 short tons	59
Methyl chloride	1945	29,702,000 pounds	60
Carbon dioxide (liquid and gas)	1945	236,084,000 pounds	59
Carbon dioxide (dry ice)	1945	659,169,000 pounds	59
Nitrous oxide	1945	119,154,000 gallons	59
Sulphur dioxide	1945	57,461,000 pounds	59
Propane	1944	335,337,000 gallons	61
Butane	1944	277,240,000 gallons	61
Butane-Propane mixtures	1944	449,192,000 gallons	61

Peak Load Conditions

The use of liquefied petroleum gases—propane, normal butane, and mixtures of propane and the two butanes—has been rather extensive, and the literature citations are numerous for meeting peak load and emergency situations, in both manufactured and natural gas consuming areas.[62] In 1928 Louisville Gas & Electric Company was faced with the possibility of a peak load in excess of 40,000 Mcf daily. Recently there has been a noteworthy expansion in the use of propane-air mixtures to supplement natural gas supplies under peak load conditions. This peak load situation and how it was met by use of liquefied butane is described in *Gas Age Record*.[63]

* * *

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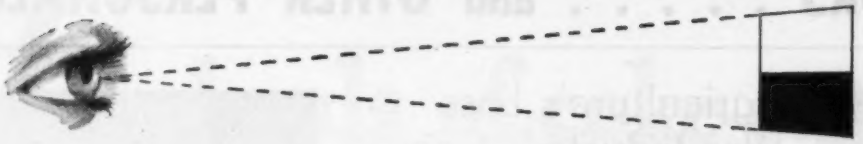

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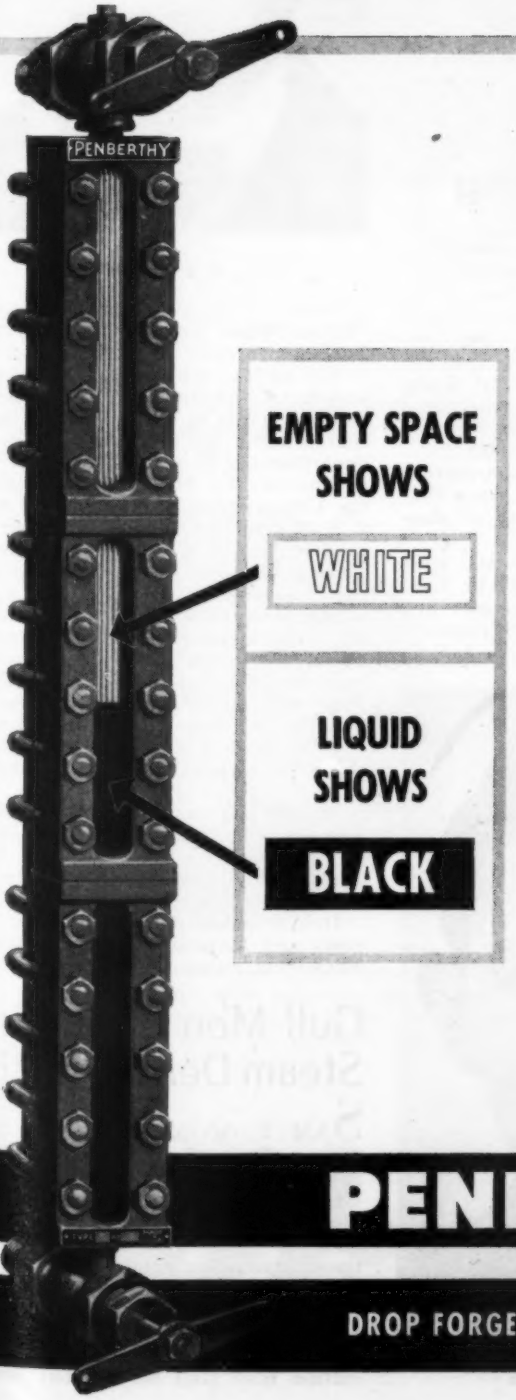

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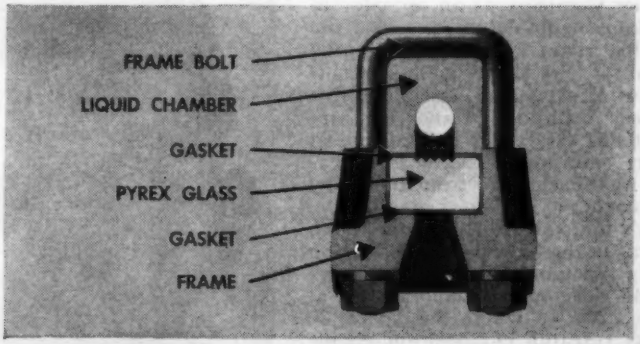

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REFINER AUTHORS . . . . . and OTHER PERSONALITIES

MARTIN SMOLAK

Diesel Fuel Topic by Ex-Varsity Gridster

MARTIN SMOLAK, co-author of the article "Evaluation of Additives and Blends for Improving the Cold Starting Characteristics of Diesel Fuels," (starts on page 75) since last February has been serving as petroleum chemical sales and service representative in San Francisco for E. I. du Pont de Nemours & Company.

After playing football for and graduation from Drexel Institute of Technology, Philadelphia, in 1939, with a B. S. in chemical engineering, Smolak was employed until 1942 by The Atlantic Refining Company as an operator in the cracking still department at the Philadelphia plant. For eight months he worked for The M. W. Kellogg Company, New York, as an assistant project engineer in the design and construction of fluid catalytic cracking units, this before entering the Navy as an ensign. He was discharged from the Navy as a lieutenant in 1946.

Smolak's first job after returning from service was in the light products division of Socony Vacuum Oil Company's research and development laboratories at Paulsboro, N. J., where he spent 20 months as research engineer on engine deposit and fuel additive studies.

Co-author with Smolak of the current article was F. L. Nelson, since 1945 engineer on the utilization of motor gasoline and diesel fuels at Socony-Vacuum's Research and Development Department at Paulsboro. He was presented on the author's page of PETROLEUM REFINER last month in connection with the study which he did with T. L. Apjohn entitled "Diesel Fuels from Catalytic Cracking Operations."

Agriculture's Loss Was Industry's Gain

THE editor, who in his youth saw something of rural ups and downs—principally the latter—liked particularly this one line from the biographical sketch which came to his desk from Allis-Chalmers Manufacturing Company regarding their water conditioning research man, Carroll E. Imhoff:

"He grew up on a farm in central Illinois and made an early decision to follow some vocation other than agriculture."

That, obviously, to use the cliche', "is putting it mildly." At any rate, we can say farming's loss was industry's gain. And, in the current case, PETROLEUM REFINER's gain, because Imhoff has contributed a most interesting article, "Boiler Water Conditioning to Prevent Turbine Deposits" (starts on page 108).

C. E. IMHOFF

The author, who since 1934 when he joined Allis-Chalmers, Milwaukee, Wis., to take charge of the laboratory and research section of the water conditioning department, was born November 1, 1907, in Danvers, Ill. He was graduated from the University of Illinois in 1931 with a B.S. degree and in the following year received an M.S. degree in chemistry. During this time he was an assistant in the engineering experiment station, working on the solubility of calcium sulfate in an experimental boiler operating up to 3000 pounds per square inch. He was on the chemical staff of the Illinois State Geological Survey between 1932 and 1934 working on mineral resources, principally coal and limestone, and on the experimental production of mineral wool.

Imhoff has written a number of articles on general feedwater treatment and on the use of x-ray diffraction in the study and solution of special water conditioning problems.

Imhoff holds patents covering processes and materials for the removal of silica from water.

Author's Activity: Apartment Hunting

S. G. ELLIS who was born in Norwich, England, is a graduate of the University of Wales where he obtained his B.Sc. in physics in 1939. He obtained his master of arts degree at the University of Toronto, Canada, in 1940 for work on the flow properties of liquid helium II, and his Ph.D. at the same university in 1946 for work in electron microscopy. (See article page 80.)

Ellis joined the RCA Laboratories, Princeton, N. J., in 1947 and since that time has worked on a variety of electron optical problems.

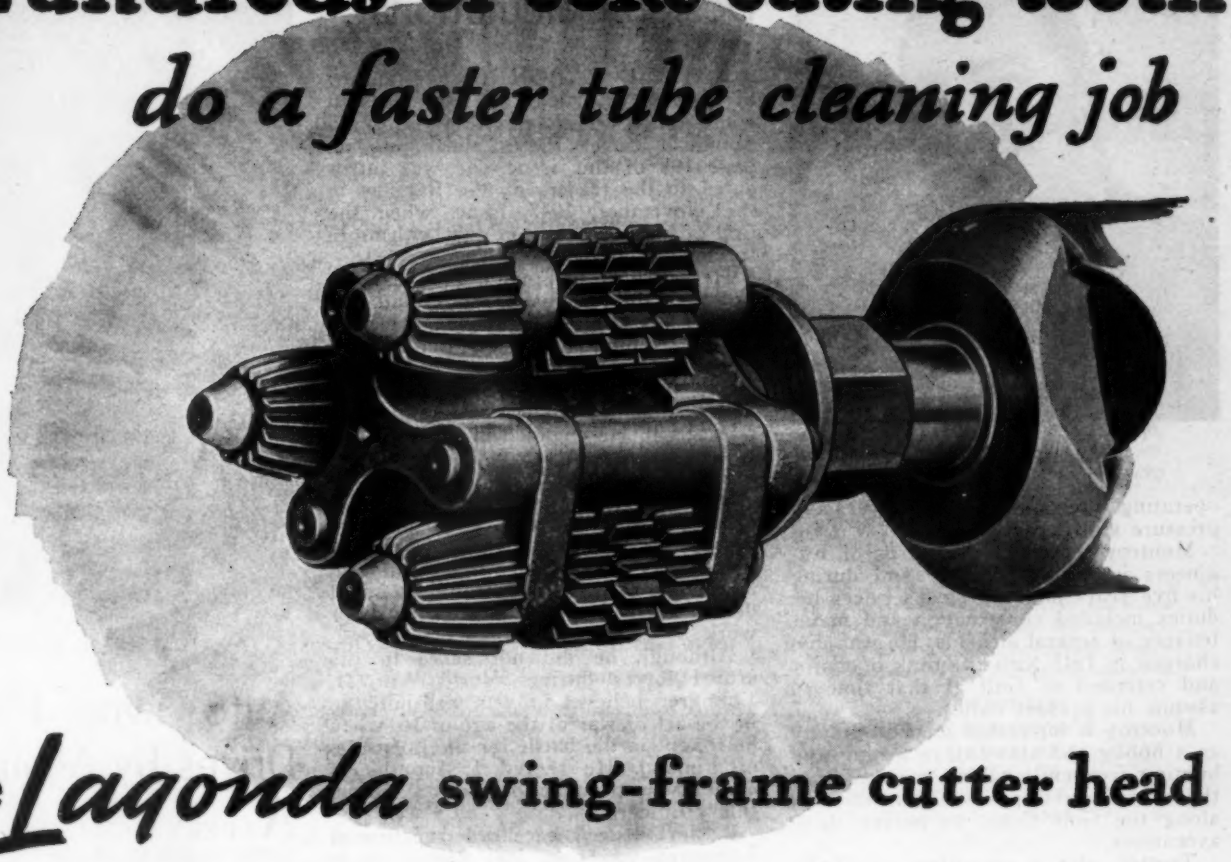
His extra curricular activities were in Wales, mountain-climbing; in Canada, fishing and getting married; and in these United States, until recently, apartment hunting.

DR. S. GLENN ELLIS

Gulf Men Contribute Steam Demand Article

SAM F. MONTROY, co-author of "Steam Demand of Direct Acting Reciprocating pumps" (see page 91) with George P. Trotter, Jr., began his employment with Gulf Oil Corporation at its Port Arthur, Texas, refinery in 1933 upon graduating from Louisiana Polytechnic Institute with a degree in electrical and mechanical engineering. Montroy is presently engaged as a utility rates control engineer. During his association with Gulf he also has been the

Hundreds of coke-eating teeth
do a faster tube cleaning job



The Lagonda swing-frame cutter head

Note the wide swing of the cutter arms — wider than in any other swing-frame head, giving plenty of latitude for any possible variation in the I.D. of the tube.

gives you in each swinging arm the **long cutting surface** of several cutters working together, comprising hundreds of sharp teeth to share the job of smashing profit-killing coke.

Of course a head like this takes a lot of **drive** to get the best out of it. This is where the husky, powerful Lagonda 1100 Series motor comes in, with its double ball thrust bearings and full lubrication that let practically **all** the power through to the cutter head, whirling its swinging arms against the coke to bite deep. Those cutters are held to the job by cutter pins locked in place by a solid slug of metal that drops into a slot in the end of the pin. No threads to jar loose and break.

Try this new Lagonda scale-smashing combination and get a new angle on figuring time-out for stills.

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SAM F. MONTROY

operating division of the power and pressure still department.

Montroy served in the Corps of Engineers in World War II and during his five years in the armed services his duties included construction and maintenance of several airfields. He was discharged in 1945 with the rank of major and returned to Gulf at that time to assume his present duties.

Montroy is interested in photography as a hobby and also enjoys fishing and hunting frequently taking advantage of the excellent opportunities afforded along the Gulf Coast to pursue these avocations.

Trotter, also a co-author of "Two-Way Flow Metering of Refinery Steam Lines," which appeared in PETROLEUM REFINER last June is a Texas Aggie. He has been either with Gulf or Uncle Sam since shortly after his graduation in 1941 from Texas A. & M. College.

Reynolds Hops Onto A Pet Topic Again

"INDUSTRIAL Engineering in Refinery Maintenance," beginning on page 86 of this issue of PETROLEUM REFINER is William H. Reynolds' third article since July of last year. His last two articles are on his pet subject.

Reynolds is with Sinclair Refining Company at the East Chicago, Ind., refinery in the maintenance department. He was graduated from Purdue University in 1938. He has worked for Shell Oil Company (Houston refinery), The Pure Oil Company, Chicago; Arthur G. McKee Construction Company, Cleveland, and Standard Oil Company (Ohio) where he was head of a then newly-formed maintenance division with duties looking toward control of all plants maintenance. This included setting up programs for improvement and cost reduction of maintenance through use of industrial engineering principles.

He is a registered professional engineer in the states of Ohio and Indiana. During the war he was a lieutenant, j.g., in the Navy serving as junior officer aboard a submarine.

Finn Still Figuring Design Calculations

HARALD E. LONNGREN, author of a series of articles on flange design construction, has another "Obround Manhead Cover Plates" beginning on page 102 of this issue. He was introduced to the readers of the REFINER in the November, 1947, issue, when the first of his series (seven now with more to come) appeared.

He was born in Finland and was educated at the Tekniska Hogskolan, receiving his "diplom ingenieur" in 1925. Before coming to the United States, Lonngren was employed in Finland as a mechanical engineer in charge of steam boiler and presure vessel design and fabrication. He engaged in similar work in this country for about 11 years.

Lonngren joined Standard Oil Development Company in 1940, where his present duties involve checking pressure vessel and heat exchanger drawings. It was in this work that he found the need for simple calculating methods to assist designers of pressure vessels in their work.

Although he did not serve in the armed forces during World War II, Lonngren believes he was well-initiated in the art of war at the age of 16, when he fought in the battle for the liberation of Finland. He served 15 months of compulsory training for the rank of artillery officer.

A shirt-sleeved, bareheaded picture of Lonngren was used last winter, so in order to be perfectly consistent here in the heat of the summer, we are showing him in an overcoat and hat.

The one-time diver and javelin thrower gets his outdoor diversion by weekend auto drives. At home he plays chess with his wife or does cross-word puzzles.

HARALD E. LONNGREN

ALBERT E. HICKEL

Auto Owner Hickel Drives By Again

ALBERT E. Hickel, consulting lubricating engineer of East Chicago, Ind., has contributed another article on lubrication for readers of PETROLEUM REFINER. His latest contribution begins on page 94, under the title, "Petroleum Rust Preventives."

Automotive lubrication has been a subject of paramount interest to Hickel for over 40 years. A native of Alsace, he started his career in this country in 1902 as a chemist in the Galena Signal plant at Franklin, Pa. Then he transferred to Galena's plant at Parkersburg, West Virginia, in 1907 to serve as superintendent until 1919. From 1919 to 1922 he was refinery superintendent at Brownwood, Texas.

He joined The Texas Company at Port Arthur, Texas, in 1922 as research lubricating engineer, leaving in 1925 to join Sinclair Refining Company as research lubricating engineer. He remained with Sinclair until 1945 at the East Chicago, Indiana, plant.

About 40 years ago, Hickel assembled a "gearless" Metz automobile, powered by a two-cylinder opposed horizontal, air-cooled motor, having a friction drive (aluminum disc against a leather-faced disc).

He literally has grown up with the auto industry, both as a lubrication expert and as an "ultimate consumer." He has owned all kinds as his collection of snapshots will attest.

It's a pity we can't reproduce some of the pictures which Hickel has of himself and his early autos. These include one of the first imported Italian cars (Isotta-Fraschina), a Mercedes-Benz circa 1905 and an early American (1908) car with side crank.

3 Ways to Check Oxidation

Du Pont Gasoline Antioxidants

These three Du Pont Gasoline Antioxidants permit you to select the antioxidant to which your gasoline will be most responsive . . . and which will best meet your refining conditions. The matching of gasoline and antioxidant can be done most effectively through experimentation. For this reason it is suggested that you obtain samples of all three for evaluation in your own laboratory. Or, if you desire, the nearest of any one of the five Du Pont Field Laboratories will conduct the tests for you on a sample of your gasoline.

If operating and storage conditions involving water contact in tank bottoms or caustic carry-over are the determining factors, you will want Du Pont Gasoline Antioxidant No. 22 since it is insoluble in water and caustic.

On the other hand, if control of copper dish gum is of major importance you should consider Du Pont Gasoline Antioxidant Nos. 5 or 6. Both of these antioxidants are excellent for this purpose.

A comparison of these antioxidants with those you are now using will prove their effectiveness. Send for samples today, or contact the Du Pont representative in your area. He will be glad to discuss your antioxidant problem with you and to assist you in selecting the one best suited to your needs.

* * *

Technical Bulletins are available on Du Pont Antioxidants Nos. 5, 6 and 22. *Write for your copies.*

No. 5 Antioxidant No. 5 is a solution containing 50% Normal-butyl-para-aminophenol, 30% Anhydrous iso-propanol, and 20% Anhydrous methanol.

PROPERTIES

Specific Gravity at 60°/60° F	0.91
Pounds per Gallon at 60° F	7.57
Flash Point (Tag C.C.) °F	60.
Viscosity at 100° F., S.U.S.	41
Solidification Temperature, °F	—20

No. 6 Antioxidant No. 6 is a solution containing 50% Iso-butyl-para-aminophenol, 30% Anhydrous iso-propanol, and 20% Anhydrous methanol.

PROPERTIES

Specific Gravity at 60°/60° F.	0.91
Pounds per Gallon at 60° F	7.57
Flash Point (Tag C.C.) °F	60
Viscosity at 100° F., S.U.S.	41
Solidification Temperature, °F	0

No. 22 Antioxidant No. 22 is a commercial grade of N,N'-disecondary butyl-para-phenylene-diamine containing no solvents.

PROPERTIES

Specific Gravity at 60°/60° F	0.94
Pounds per Gallon at 60° F	7.67
Flash Point (C.O.C.) °F	290
Viscosity at 100° F., S.U.S.	64
Solubility in Water at 80° F., Weight %	<0.05
Solubility in Gasoline at 80° F	In all proportions

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Refinery and Other Plant Construction

Companies whose projects are not listed or readers who know of unlisted projects are urged to: 1) send in data on units not shown herein; 2) furnish details which are missing in the current tabulation and 3) report from time to time on progress of such work. Such cooperation will be very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Esso Standard Oil Co.	Linden, New Jersey	Vac. pipe still	40,000 bbls.	.....	Under Constr.	1st half, 1949	.....	S.O.D. & Braun	Braun
Esso Standard Oil Co.	Linden, New Jersey	Cat. Crack, Light Ends	41,000 bbls.	.....	Under Constr.	1st half, 1949	.....	S.O.D., Braun	Braun
*Esso Standard Oil Co.	Bayonne, N.J.	Dewaxing	7,500 bbls.	.....	.....	1st Qtr., 1949	.....	Badger	Badger
Gulf Oil Corp.	Philadelphia, Pa.	Naphtha, Polyform	16,000 bbls. (circ.)	.....	Under Constr.	Oct., 1948	Gulf-Phillips	Lummus	Lummus
Gulf Oil Corp.	Philadelphia, Pa.	Topping and Vacuum Unit	30,000 bbls.	.....	Under Constr.	Sept., 1949	.....	Lummus Badger	Lummus
Kendall Ref. Co.	Bradford, Pa.	De-ethanizing Tower	50 bbls.	$15,000	Material on Order	Sept., 1948	.....	.....	.....
The Pennzoil Co.	Rouseville, Pa.	Boiler House add.	.....	.....	Contracted	Late 1948	.....	Dravo Corp.	Union Iron Wks. and Dravo
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Lube Plant	.....	.....	Under Constr.	Mid 1949	Juik	Badger	Badger
*Socony-Vacuum Oil Co.	Paulsboro, N.J.	Propane Deasphalting	5950 bbls.	.....	Under Constr.	Mid 1949	Juik	Badger	Badger
*Socony-Vacuum Oil Co.	Paulsboro, N.J.	Furfural Refg.	4450 bbls.	.....	Under Constr.	Mid 1949	Texaco	Badger	Badger
*Socony-Vacuum Oil Co.	Paulsboro, N.J.	MEK Dewaxing	2050 bbls.	.....	Under Constr.	Mid 1949	Texaco	Badger	Badger
L. Sonneborn Sons, Inc.	Petrolia, Pa.	Enlarge Acid Plant, Anti-Pollution	.....	$400,000	Approved	1948-49	.....	Chemical Constr. Co.	Morris Knowles & Co.
Sun Oil Co.	Marcus Hook, Pa.	Wax	.....	.....	Under Constr.	1948	Texaco	Staff	.....
*Sun Oil Co.	Marcus Hook	Comp. & Pkg.	.....	.....	Under Constr.	1948	.....	Staff—Lindsay	W. W. Lindsay
The Texas Co.	Eagle Pt., New Jersey	Vac. still, Cat. Cracking	40,000 bbls.	.....	Contract let	Late '49	.....	Kellogg, Texaco	Kellogg, Foster-Wheeler
*Tidewater Associated Oil Co.	Bayonne, N.J.	Revamping Houdry Fixed Bed Unit	.....	.....	Under Constr.	.....	Houdry	Houdry	Cat. Constr.
U.S.Dept. of Interior	Bruceton, Pa.	Fischer-Tropsch Pilot Plant (Coal-to-gasoline synthesis)	5 bbls.	.....	Contracted	.....	.....	Blaw-Knox Co.	Blaw-Knox Co.
MID-CONTINENT									
Ashland Oil and Refining Co.	Ashland, Ky.	Revamping TCC Kiln and Reactor	.....	.....	Under Constr.	.....	Houdry	Cat. Constr.	Cat. Constr.
*Ashland Oil & Refg. Co.	Ashland, Ky.	Revision & Modernization of Refg. Units	.....	$500,000	Under Constr.	Jan., 1949	.....	Staff	Staff
Barsco Oil Co.	Wichita Kans.	L. P. G.	250 bbls.	$100,000	Under Constr.	Sept., 1948	.....	Born	Born
Berry Asphalt Co.	Stephens, Ark.	Expand Asphalt Plant	2,000 bbls.	.....	Under Constr.	Aug., 1948	.....	Staff	Staff
Berry Asphalt Co.	Waterloo, Ark.	Lub Unit, Expand Asphalt facilities	1,200 bbls.	.....	Under Constr.	Aug., '48	.....	Process Eng.	Process Eng.
Cities Service Oil	Chicago	Compounding & Grease Plant	1,500 bbls.	$2.5 million	Design	Early '49	.....	Sumner-Sollitt	.....
Cities Service Oil Co. (Delaware)	E. Chicago, Ill.	Modernise Plant	.....	$18 million	Under Constr.	Late '48	Kellogg	Kellogg	Kellogg
Cities Service Oil Co. (Delaware)	E. Chicago, Ill.	Laboratory	.....	$300,000	Under Constr.	July, '48	.....	Staff	Sumner-Sollitt
Consumer Co-operative Association	Coffeyville, Kansas	MEK Dewaxing	2,500 bbls.	$1.5 million	Contracted	1949	Texaco	Process Eng.	Process Eng.
*Continental Oil Co.	Ponca City, Okla.	Repair & Revision to Cat Crackers	22,500 bbls.	$944,000	Under Constr.	Jan., 1949	Houdry	Cat. Constr.	Cat Constr.
Dewase Oil Co.	Weston, Ohio	Lube filtering unit, Desalting	250 bbls., 800 bbls.	$15,000	Under Constr.	Aug., 1948	Petroco	Staff	Staff
Fen-Ter Refg. Co.	Wynnewood, Okla.	Enlarge Asphalt Plant	8,000 bbls.	$250,000	Under Constr.	July, 1948	.....	Ref. Eng.	Ref. Eng.
Fen-Ter Ref. Co.	Wynnewood, Okla.	Asphalt Specialties Plant			Under Constr.	July, 1948	.....	Ref. Eng.	Ref. Eng.
Gulf Refg. Co.	Toledo, O.	Top & Vac. Unit	32,000 bbls.	.....	Under Constr.	Feb., 1949	.....	Badger	Badger
Gulf Refg. Co.	Toledo, O.	Fluid Cat. Crk.	15,500 bbls.	.....	Under Constr.	May, 1949	.....	Kellogg	Kellogg
Gulf Refg. Co.	Toledo, O.	Polymerization Unit	5,000 bbls.	.....	Under Constr.	May, 1949	U.O.P.	Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati	Fluid Unit	15,500 bbls.	.....	Under Constr.	June, 1949	.....	Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati	Polyform Plant	5000 bbls.	.....	Under Constr.	June, 1949	U.O.P.	Kellogg	Kellogg
Hagy, Harrington & Marsh	Hooker, Okla.	Gasoline and LPG Recovery	100,000 mcf	$2 million	Under Constr.	July 1, '48	.....	Pritchard	Pritchard
Harrington & Marsh	Panoma, Okla.	Natural Gasoline & L.P.G. Plant	100,000 mcf.	$2 million	Under Constr.	Aug., 1948	.....	Pritchard	Pritchard
Hiwan Oil Co.	Magnolia, Ark.	Gasoline Plant	10,000 mcf	.....	First Stage Completed	.....	.....	Petro. Eng.	Petro. Eng.
Indiana Farm Bureau Co-op Assn., Inc.	Mt. Vernon, Ind	Enlarge Topping Unit	7,000 bbls.	.....	.....	Sept., 1948	.....	.....	Staff
Kanotex Refg. Co.	Arkansas City, Kans.	Cat Cracking	4,200 bbls.	$500,000	Under Constr.	Nov., 1948	Phillips	Koch Eng.	Koch Eng.
Lion Oil Co.	El Dorado, Ark.	Enlarge Ammonia Unit	570 tons	$3.5 million	Under Constr.	June, 1949	.....	Chem. Const.	Chem. Const.
*Lion Oil Co., Opr.	Schuler, Union County, Ark.	Deethaniser (Propane Rec. Unit)	5000 gals.	$125,000	Under Constr.	Sept., 1948	.....	Staff	O. L. Olsen
*Lion Oil Co., Opr.	Schuler, Union County, Ark.	Extend Compressor Plant	4800 h.p.	$85,000	Under Constr.	Sept., 1948	.....	Staff	O. L. Olsen
M.F.A. Oil Co.	Chanute, Kans.	Desulfurization	1,000 bbls.	$75,000	.....	Jan., 1949	Phillips	Koch	Staff
Magnolia Pet. Co.	Grant County, Kans., (Hickok)	Gasoline Plant	100,000 mcf	.....	Design	June, 1949	.....	.....	.....
Magnolia Pet. Co.	Grady County, Okla.	Gasoline Plant	30,000 mcf	.....	Design	.....	.....	.....	.....

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Mid-Continent Pet. Co.	Tulsa, Okla.	Vac still, Cat Cracking	13,500 bbls.	$8.5 million	Contract let	Oct., 1948	Kellogg	Kellogg	Kellogg
Midland Cooperative Wholesale	Cushing, Okla.	Thermal Reforming	1,400 bbls.	Part of $500,000	Under Constr.	Jan., 1949	U.O.P.	U.O.P., Ref. Eng.	Ref. Eng.
Midland Cooperative Wholesale	Cushing, Okla.	Increase Topping Capacity	6,500 bbls.	Part of $500,000	Under Constr.	Aug., 1948	U.O.P.	U.O.P., Ref. Eng.	Ref. Eng.
Ohio Oil Co.	Robinson, Ill.	Vac Unit, Cat Crack, Crude Still, Poly, LP G Recovery	27,500 bbls.	$15 million	Under Constr.	Late '48	U.O.P.	McKee	McKee, Pritchard
Old Dutch Ref. Co.	Muskegon, Mich.	LPG Recovery	3,400 gallons	$45,000			U.O.P.	Staff	Staff
Old Dutch Ref. Co.	Muskegon, Mich.	Crack Plant Revamp	800 bbls.	$30,000	Under Constr.	July 1948	U.O.P.	Staff	Staff
Osceola Refining Co., Inc.	Reed City, Mich.	T.E.L. Blending plant	1,000 bbls.	$25,000	Under Constr.	July, 1948		Staff	Staff
*Owens, Libbey-Owens Gas Dep't	So. Malden, West Va.	Butane, Propane Column	6000 gals.	$50,000	Design	Dec., 1948		Staff	Staff
Peteo Corporation	Blue Island, Ill.	Skim, & Crk.	10,000 bbls.		Under Constr.	Summer, '48		Clark's	Clark's
Petroleum Specialties, Inc.	Flat Rock, Mich.	Increasing distillation, and other plant facilities	6,000 bbls.	$50,000	Under Constr.	Fall, 1948		Staff	Staff
Phillips Pet. Co.	Kansas City, Kans.	Compounding Plant			Under Constr.	Oct., 1948		Staff	Winn-Senter
Phillips Pet. Co.	Kansas City, Kans.	Lubricating Unit	1,500 bbls.		Under Constr.	Nov., 1948		Kellogg	Kellogg
Phillips Pet. Co.	Kansas City, Kans.	Cat. Crack	24,000 bbls.		Under Constr.	Oct., 1949		Braun	Braun
Phillips Pet. Co.	Kansas City, Kans.	Cat. Poly	1,500 bbls.		Under Constr.	Oct., 1949		Braun	Braun
Phillips Pet. Co.	Guymon, Okla.	Absorption Plant	173,000 mcf		Authorized	July, 1949			
Rock Island Refg. Corp.	Rock Island, Ind.	Fluid Cat, Crk.	10,000 bbls.	$1,200,000	Contracted	July, 1949	U.O.P.	U.O.P.	Staff
Louis Rose Refining Co.	Saginaw, Mich.	Storage Terminal on Saginaw River	100,000 bbls.		Under Constr.	Aug., 1948			Meager Bros., General American
Sinclair Refg. Co.	E. Chicago, Ill.	Crude, Cat. Cracker, Poly Plant & Lube Treating	55,000 bbls.		Under Constr.	Late, '48		Lummus, Braun, Sinclair	Braun, Lummus
Skelly Oil Co.	Eldorado, Kans.	Crude Dist. Unit, Cat. Crk.	30,000 bbls.		Announced	Jan., 1950			
Skelly Oil Co.	Stephens Co., Okla.	Gasoline Plant							Born
Socony-Vacuum Oil Co., Inc.	E. St. Louis, Ill.	Crude Thermal Crack.			Under Constr.	Oct., 1949		Bechtel Corp.	Betchel Corp.
*Sohio Petroleum Co.	Covington, Ky.	Waste Water Separator	7.2 million gals.			Aug., 1948		Staff	Dawson-Evans, Foster Wheeler, Nolan Co. Dingle-Clark Co.
Standard Oil Co., (Indiana)	Sugar Creek, Missouri	Cat Cracking	25,000 bbls.			Mid '48			Kellogg
Standard Oil Co., (Indiana)	Whiting, Ind.	Motor Oils Unit			Under Constr.	Mid 1948			Foster-Wheeler, Stone & Webster Kellogg
Standard Oil Co., (Ohio)	Lima, Ohio	Cat Cracking	16,000 bbls.	$11 million	Under Constr.	Late '49	U.O.P.	McKee	McKee
Standard Oil Co. (Ohio)	Lima, Ohio	Crude Distl., Coke	†15,000 bbls.	$5 million	Announced				
Stanolind O & G Co.	Garden City, Kans.	Hydrocarbon Synthesis	100,000 mcf		Under Constr.	Jan., 1950		Hydro Research, J&L Constr.	Kellogg, Foster-Wheeler, Stone & Webster, J & L Constr.
Stanolind O & G Co.	Garden City, Kans.	Chemical Plant	130,000 lbs./yr.		Contracted	Jan., 1950		Badger	Badger
Stanolind O. & G. Co.	Ulysses, Kans.	Gasoline Plant	100,000 mcf		Under Constr.	Fall, '48		J & L Constr.	J & L Constr.
Sun Oil Co.	Toledo, Ohio	Cat. Crack Crude Dist., Vac., Poly.	30,000 bbls.	$16 million	Under Constr.	1950	Houdry	Houdry, Cat. Constr., Process Eng., Staff	Cat. Constr.
Sun Oil Co.	Toledo, Ohio	Anti-Pollution Project		$600,000				Sun Oil	Cat. Constr.
The Texas Co.	Lawrenceville, Illinois	Crude and Cat Cracking	20,000 bbls.		Site being Cleared	1950		Foster-Wheeler	Kellogg, Foster-Wheeler
The Texas Co.	W. Tulsa, Okla.	Crude and Cat Cracking	30,000 bbls.		Contract let	1949		Staff, Kellogg, Foster-Wheeler	Kellogg, Foster-Wheeler
Trans-Marine O. Refg. Co.	S. Milwaukee, Wis.	Crude, Vac., Refrm, Desulf.	5,000 bbls.	$1.3 million	Under Constr.				Ref. Eng.
U.S. Dept. of Interior	Louisiana, Mo.	Demonstration Oil-from-Coal Plant	80 bbls.	$4.4 million	Contracted	Oct., 1949		Koppers	Koppers
Warren Pet. Corp.	Madill, Okla.	Gaso. Plant Enlargement	1,500 bbls.		Projected	Jan. 1, 1949		Hudson	Hudson
Warren Pet. Corp.	Maysville, Okla.	Gasoline Plant	8,000 bbls.		Under Constr.	Jan. 1, 1949		Dresser	Dresser
Wood River Oil & Refg. Co.	Hartford, Ill.	Cat Cracking gasoil, Cracking	8,500 bbls.	$1 million	Under Constr.	Late '48	Phillips	Koch Eng.	Koch Eng.
SOUTHWEST									
Alamo Ref. Co.	Sweeny, Texas	LPG Fractionation			Authorized	Fall, 1948			
Alamo Refining Co.	Sweeney, Texas	Cat Cracker Revision		$150,000	Contract let			Phillips	Mason
American Republics Corp.	Silsbee, Texas	Gasoline and Cycling	56,000 mcf	$3 million	Under Constr.	Aug., 1948		Gaso. Plant	Gaso. Plant
Arkla Oil Co.	Rodessa, La.	Add Compressors	60,000 mcf	$325,000					Staff
Calumet Refg. Co.	Princeton, La.	Modernization of Lube Plant	700 bbls.		Under Constr.	Early '49		Staff	Staff
Carthage Corp.	Carthage, Field	Gasoline Plant	100,000 mcf	$3.5 million	Under Constr.	Jan. 1, '49		Hudson	Hudson
Carthage Hydrocol, Inc.	Brownsville, Tex.	Hydrocol	64,000 mcf	$19 million	Under Constr.	1948	Hydro-Res. Inc Texaco	McKee	McKee
The Chicago Corp.	Carthage, Tex.	Enlarge Gas. Plt.	210,000 mcf	$2 million	Authorized	June, 1949		Staff	
Cit-Con Corp.	Lake Charles, La.	Lube Plant	6,000 bbls.	$35 million	Under Constr.	Mid 1949	Texaco, Max B. Miller	Max B. Miller Lummus,	Lummus, Max B. Miller
Cities Service Oil Co.	Pampa, Texas	Gasoline Plant	18,000 mcf		Contracted	1949		Waleo	Waleo
Continental Oil Co.	Sonora, Texas	Gasoline Plant	10,000 mcf	$2.5 million	Contracted	July, 1949		Ref. Maint.	Ref. Maint.
*Conden Pet. Corp.	Big Spring, Tex.	Fluid Cat. Plant	6000 bbls.		Being Engineered	Jan., 1950	UOP	UOP	Ref. Eng.
Duval Gasoline Co.	Benevidas, Texas	Adsorption Plant	10,500 mcf.	$100,000	Under Constr.	Late 1948		Republic Oil Ref. Co.	Staff
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends Recovery	20,000 mcf		Under Constr.	Last Qtr., 1948		S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Polymer	4,000 bbls.		Under Constr.	3rd Qtr., 1948		S.O.D., McKee	McKee

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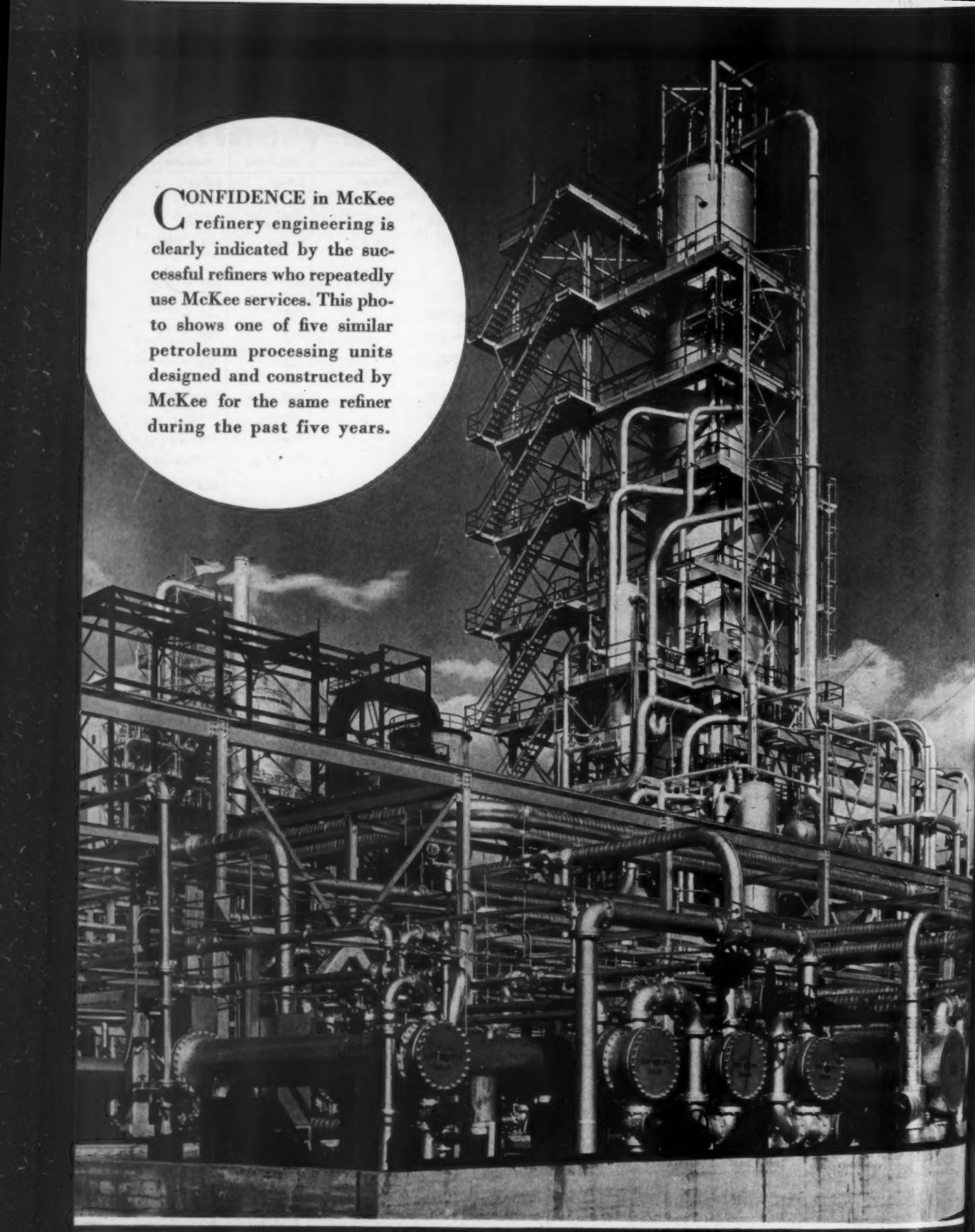

CONFIDENCE in McKee refinery engineering is clearly indicated by the successful refiners who repeatedly use McKee services. This photo shows one of five similar petroleum processing units designed and constructed by McKee for the same refiner during the past five years.

McKEE

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DESIGN, ENGINEERING AND CONSTRUCTION FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

UNDIVIDED RESPONSIBILITY IN ONE ORGANIZATION

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Esso Standard Oil Co.	Baton Rouge, La.	Pipe Still	58,000 bbls.	.....	Under Constr.	3rd Qtr., 1948	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Vacuum Pipe Still	18,500 bbls.	.....	Under Constr.	3rd Qtr., 1948	.....	Braun	Braun
Esso Standard Oil Co.	Baton Rouge, La.	Vacuum Pipe Still	14,500 bbls.	.....	Under Constr.	Last Qtr., 1948	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends Recovery	11,000 bbls.	.....	Under Constr.	1st Qtr., 1949	.....	Braun	Braun
Ethyl Corp.	Baton Rouge, La.	Mfg. Facilities	.....	$20 million	Announcement	.....	.....	.....	.....
Gilcrease Oil Co.	Arabi, La.	Skimming	6,000 bbls.	$250,000	Under Constr.	July 15, 1948	.....	Ampco	Ampco
Gray-Wolfe Co.	Montgomery Co.	Gasoline Plant	13,000 mcf	$2 million	Under Constr.	Jan., 1949	.....	O. L. Olsen	O. L. Olsen
Gulf Oil Corp.	Crane, Texas	Gasoline Plant	40,000 mcf	.....	Contracted	Fall, 1949	.....	Braun	Braun, W. D. Bowden
Gulf Oil Corp.	Pt. Arthur, Tex.	3 Top & Vac. Units	22,000 bbls. ea.	.....	Under Constr.	Aug., 1948	.....	Badger	Badger
Gulf Oil Corp.	Pt. Arthur, Tex.	Cat. desulf.	17,000 bbls.	.....	Under Constr.	.....	.....	Lummus	Lummus
Gulf Oil Corp.	Pt. Arthur, Tex.	Naphtha Polyform.	32,000 bbls. circ.	.....	Under Constr.	Aug., 1948	.....	Lummus	Lummus
Humble O. & R. Co.,	Overton, Texas (London Plant)	Add Propane, Absorption Refrigeration	Gas	.....	Under Constr.	Aug., 1948	.....	Fish Eng.	Fish Eng.
Humble O. & R. Co.,	Overton, Texas (American Plant)	Add Propane, Absorption	Capacity	$2 million	Under Constr.	Aug., 1948	.....	Fish Eng.	Fish Eng.
Humble O. & R. Co.,	Laird Hill, Texas (Kilgore Plant)	Add Propane, Absorption—Refrigeration	Unchanged		Under Constr.	Aug., 1948	.....	Fish Eng.	Fish Eng.
Humble O. & R. Co.,	Katy, Texas	Add Propane, Absorption	.....	$7 million	Under Constr.	March, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O. & R. Co.	Kelsey Field, Texas	Gas Injection Plant	18,000 mcf	$1,408,000	Under Constr.	Jan., 1949	.....	Stearns-Roger	Stearns-Roger
Humble O. & R. Co..	Seeligson Field, Texas	Gas Injection Plant	20,000 mcf	$1,336,000	Under Constr.	Jan., 1949	.....	Stearns-Roger	Stearns-Roger
Humble O. & R. Co..	Conroe, Texas	Add Compression—Absorption	30,000 mcf	$4,160,000	Under Constr.	Summer, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O. & R. Co..	Bloomington, Texas	Gas Comp. Plant	22,000 mcf	.....	Authorized	1949	.....	.....	.....
Humble O. & R. Co..	Opelousas, La.	Absorption Plant	100,000 mcf	$2,800,000	Authorized	Spring, 1949	.....	.....	.....
Humble O. & R. Co..	Pickton Field, Texas	Comp.—Absorp. Plant	18,000 mcf	$2,133,000	Authorized	Spring, 1949	.....	Fluor	Fluor
*Humble Oil & Refg Co.	Baytown, Texas	Pipe Stills	45,000 bbls.	$5.8 million	Authorized	Late 1949	.....	Foster Wheeler	Foster Wheeler
*Humble Oil & Refg Co.	Baytown, Texas	Lube Extraction	7000 bbls.	$5.3 million	Authorized	Late 1949	.....	Kellogg	Kellogg
Hutex Oil & Ref.	Hardin, Texas	Crude & Product Storage Facilities, Control House	20,000 bbls.	$75,000	Under Constr.	Sept., 1948	.....	Staff	.....
Magnolia Pet. Co...	Beaumont, Tex.	Lube Plant	.....	.....	Under Constr.	Jan. 1, 1949	Texaco	Lummus	Lummus, Kellogg
Magnolia Pet. Co...	Seeligson Field, Texas	Gasoline and Cycling	70,000 mcf Casinghead 150,000 mcf Cycled	.....	Under Constr.	April, '49 Partly Completed	.....	Hudson	Hudson
Magnolia Pet. Co...	Mamou, La.	Gasoline Plant	7,000 mcf	.....	Under Constr.	Late '48	.....	Staff, Gaso. Plant	Gaso. Plant
McCarthy Chemical Co.	Winnie, Texas	Petro Chem	.....	$3 million	Under Constr.	.....	.....	Staff	Tellepsen
Monsanto Chem. Co.	Texas City, Tex.	Rebuilding Petro-chem	.....	$6 million	Contract let	Aug., 1948	.....	.....	Bellows, Leonard
*Paluxy Asphalt Co.	Mississippi	Cracking Still	1500 bbls.	.....	Under Constr.	Sept., 1948	.....	.....	.....
Peteo Corporation..	Marrero, La.	Skim & Crk	5,000 bbls.	.....	Under Constr.	Early '48	.....	Clark's	Clark's
Phillips Pet. Co....	Andrews, Texas	Absorption Plant	24,000 mcf.	.....	Under Constr.	Oct., 1948	.....	.....	.....
Phillips Pet. Co....	Alvin, Texas	Absorption Plant	120,000 mcf	.....	Authorized	Sept., 1949	.....	.....	.....
Phillips Pet. Co....	Dumas, Texas	Absorption Plant	55,000 mcf	.....	Under Constr.	Sept., 1948	.....	.....	.....
Phillips Pet. Co....	Goldsmith, Tex.	Absorption Plant	†48,000 mcf	.....	Under Constr.	Nov., 1948	.....	.....	.....
Pioneo Co.	Auga Dulce Field	Processing Plant	30,000 mcf	$1 million	Under Constr.	"Soon"	.....	.....	.....
Pure Oil Co.	Nederland, Texas	MEK Dewaxing, Clay Contact	3500 bbls.	.....	Under Constr.	March, 1949	Texaco	Lummus	Lummus
Republic O. Refg. Co.	Texas City, Texas	Recondition Cat. Cracker	.....	$750,000	Under way	Aug., 1948	U.O.P.	Republic, U.O.P.	Mason
Republic O. Refg. Co.	Texas City, Texas	Poly Plant	.....	.....	Under Constr.	Aug., 1948	U.O.P.	Republic, U.O.P.	Mason
Shamrock Oil & Gas Co.	Sunray, Texas	Increase Topping & Cracking Facilities	10,000 bbls.	$300,000	Under Constr.	Oct., 1948	U.O.P.	Staff	Staff
Sid Richardson Gasoline Co.	Keystone Field, Texas	Gasoline Plant	107,000 mcf.	.....	Under Constr.	Jan., 1949	... ...	J & L Constr.	J & L Constr.
Shell Chemical Corp	Houston, Texas	Ethyl Chloride & Hydrochloric acid Unit	.....	.....	Completed	.....	.....	Kellogg	Kellogg
Shell Chemical Corp	Houston, Texas	Ethyl Alcohol Unit	.....	.....	Completed	.....	.....	Braun	Braun
Shell Chemical Corp	Houston, Texas	Ethyl Chloride Unit No. 2	.....	.....	Under Constr.	Sept., 1948	.....	Kellogg	Kellogg
Shell Chemical Corp	Houston, Texas	Sec. Butyl Alc. & M.E.K. Unit	.....	.....	Completed	.....	.....	Braun	Braun
Shell Chemical Corp	Houston, Texas	Glycerine Unit	.....	.....	.....	July, 1948	.....	Braun	Braun
Shell Chemical Corp	Houston, Texas	Hexylene Glycol Unit	.....	.....	Completed	June, 1948	.....	Kellogg	Kellogg
Shell Chemical Corp	Houston, Texas	Ethylene Preparation Unit	.....	.....	Completed	.....	.....	Stone & Webster	Stone & Webster
*Shell Chemical Corp.	Houston, Texas	Add Acetone Unit	.....	.....	Design	Late 1949	.....	Braun	Braun
Shell Oil Co.	Notrees, Texas	Gasoline Plant	45,000 mcf	$5 million	Under Constr.	Early '48	.....	Brown & Root	Brown & Root
Shell Oil Co.	Houston, Texas	Lube Unit	2,800 bbls.	.....	Under Constr.	Aug., '48	Texaco	Lummus	Lummus, Kellogg, Fluor
Shell Oil Co.	DenverCity, Tex.	Gasoline Plant	2,400 mcf	$1.6 million	Under Constr.	Fall, 1948	.....	Fluor	Fluor
Shell Oil Co.	Norco, La.	Thermal Cracking, Asphalt Plt	12,000 bbls.	.....	Under Constr.	1948	.....	Shell	Shell
Sinclair Refg. Co.	Houston, Texas	Crude Still, Barrel House, Grease Works	30,000 bbls.	.....	Under Constr.	.....	.....	.....	Fluor
Southwestern Oil & Refg. Co.	Corpus Christi, Texas	Catalytic Reforming	5,000 bbls.	$800,000	Under Constr.	Aug. '48	.....	Process Eng.	Process Eng.
Stanolind O. & G. Co., Opr.	Fullerton Field, Texas	Gasoline Plant	.....	.....	Approved	.....	.....	J & L Constr.	J & L Constr.
Stanolind O & G Co., Opr.	Slaughter, Hockley Co., Texas	Gasoline Plant	90,000 mcf	.....	Under Constr.	Feb., 1949	.....	Braun	Braun
Stanolind O & G Co.	Brownsville, Tex.	Chemical Plant	130,000 lbs./yr.	.....	Contracted	1949	.....	Badger	Badger
Stanolind O & G Co.	Pettus, Texas	Cycling Plant	166,000 mcf.	.....	Under Constr.	1949	.....	J & L Constr.	J & L Constr.
Sun Oil Co.	Richland Parish, Louisiana	Gasoline Plant	70,000 gal.	.....	Under Constr.	Sept., '48	.....	.....	Pet. Eng.

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Sun Oil Co.	Starr Co., Tex.	Gasoline Plant	25,000 mcf	$4 million	Under Constr.	Early 1949	Pet. Eng.	Pet. Eng.	Pet. Eng.
*Sun Oil Co.	Jameson Field, Coke County, Texas	L.P.G. Extraction	10,000 mcf	Part of $12 million	Contracted	March, 1949	.....	.....	Pritchard
Talco Asphalt & Refining Division American Liberty Oil Co.	Mt. Pleasant, Texas	Poly LPG Plant	2,800 mcf.	$285,000	Under Constr.	Aug., 1948	U.O.P.	Staff	Staff, Piping-State Eng. Co.
The Parade Co.	Rusk County, Texas	Add Propane Recovery	18,000 mcf	$250,000	Contracted	Dec., 1948	.....	Hudson	Hudson
The Texas Co.	Port Arthur, Texas	Lube & Wax Additions	2,500 bbls. oil	.....	Under Constr.	Late '48	.....	Staff, Foster-Wheeler	Foster-Wheeler
*The Texas Co.	Electra, Texas	Gasoline Plant	2,000 mcf	.....	Projected	Jan., 1949	.....	Texaco	.....
The Texas Co.	Lafitte, La.	Expand Gaso-Plant	6,500 mcf	.....	.....	.....	.....	Hudson	Hudson
Texoma Natural Gas Co.	Stinnett, Texas	Additional Compression	150,000 mcf.	$2.5 million	Under Constr.	Jan., 1949	.....	.....	Midwestern Construction Co.
United Gas Co.	Carthage, Tex.	2nd Gas Plant	100,000 mcf	$3.5 million	Under Constr.	July, 1949	.....	Hudson	Hudson
U.S. Ind. Chemicals Co.	Brownsville, Texas	Petrochemical Plant	.....	.....	Contracted	1949	.....	Badger	Badger
Waggoner Est. Ref.	Electra, Tex.	Crack Unit Revisions	.....	$250,000	Under Constr.	Fall, 1948	.....	Ref. Eng.	Ref Eng.
Warren Pet. Corp.	Breckenridge, Texas	LPG Extraction	1,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Staff	Staff
*Warren Pet. Corp.	Gladewater, Tex.	LPG Extraction	.....	.....	Contract Let	March, 1949	.....	J. B. Gill Co.	J. B. Gill Co.
Warren Pet. Corp.	Hawkins, Texas	Plant Enlargement	20,000 mcf	.....	Contract let	March, 1949	.....	Gaso. Plant	Gaso. Plant
Warren Pet. Corp.	Holliday, Tex.	Expansion & Propane prod.	2,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Staff	Staff
Warren Pet. Corp.	Taylor's Corner, Texas	Gasoline Plant	5,000 mcf	.....	Contract let	March , 1949	.....	Walco	Walco
Witco Hydrocarbon Corp.	Big Lake, Tex.	Gasoline Plant	2,500 bbls.	$2.6 million	Under Constr.	July '48	.....	Staff	Fish Eng
Witco Hydrocarbon Corp.	Witco, Texas	Carbon Black	.....	Part of $3.5 million	Contracted	.....	.....	Fish Eng.	Fish Eng., Staff
ROCKY MOUNTAIN									
The California Oil Company	Rangely, Colo.	Gasoline Plant	25,000 mcf	$3 million	Under Constr.	Late 1948	.....	Hudson	Hudson
The Carter Oil Co.	Billings, Mont.	Crude Cat Crk	30,000 bbls.	$20 million	Under Constr.	3rd Qtr. 1949	.....	U.O.P., S.O.D., Fluor	Fluor
Continental Oil Co.	Billings, Mont.	Complete Ref., Cat. Crack	7,500 bbls.	$8.5 million	Under Constr.	1949	U.O.P.	U.O.P., J. & L. Constr.	J & L Constr
Continental Oil Co.	Denver, Colo.	Crude, Cat Crk.	7,500 bbls.	$4 million	Under Constr.	Fall 1948	Houdry, U.O.P.	Staff	Lummus
Gulf Oil Corp.	Eunice, N.M.	Gasoline Plant	.....	.....	.....	.....	.....	Hudson	Hudson
New Mexico Asphalt Rfg. Co.	Artesia, N.M.	Crude Unit	7,500 bbls.	$350,000	Material Ordered	Feb., 1949	.....	Geo. Armistead	Staff
Phillips Pet. Co.	Oil Center, N.M.	Absorption Plant	†48,000 mcf	.....	Under Constr.	Nov., 1948	.....	.....	.....
Salt Lake Refg. Co.	Salt Lake City	Crude Dist. Unit	25,000 bbls.	$5 million	Under Constr.	Nov., 1948	.....	.....	Bechtel
Skelly Oil Co.	Lea County N.M.	Expanding Gasoline Plant	60,000 gals.	.....	.....	.....	.....	.....	J. E. Carlson
Socony-Vacuum Oil Co., Inc.	Casper, Wyo.	T C C	6,900 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Staff	Cat. Constr.
Southern Union Gas Co.	Bloomfield, N. M.	Gasoline Plant	20,000 mcf	$1 million	Contracted	June, 1949	.....	Ref. Maint.	Ref. Maint.
Standard Oil Co. (Indiana)	Casper, Wyo.	Cat. Crack.	8,000 bbls.	.....	Under Constr.	Early 1949	.....	.....	Kellogg
Stanolind O & G Co.	Elk Basin, Wyo.	Gasoline Plant	12,000 mcf	.....	Under Constr.	April, 1949	.....	Stone & Webster	Stone & Webster
U. S. Bureau of Mines	Rifle, Colo.	Shale Oil Refy.	3,000 bbls.	$450,000	Under Constr.	Fall, 1948	.....	Ref. Eng.	Ref. Eng.
Utah O. Ref. Co.	Salt Lake City, Utah	Propane Deasphalting	10,500 bbls.	$2.5 million	Contracted	Early 1949	.....	Kellogg	Kellogg
Warren Pet. Corp.	Monument, N.M.	Gasoline Plant Enlargement	2,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Warren	Dresser Eng.
WEST COAST									
Barnsdall Oil Co.	Newhall, Calif.	Gasoline Plant	40,000 mcf.	$1 million	Under Constr.	July, 1948	.....	Ref. Maint.	Ref. Maint.
California Asphalt Corp.	Portland, Ore	Airblown Stills, Tanks	.....	$150,000	Under Constr.	Dec., 1948	.....	.....	Staff
Coline Gasoline Co.	Ventura, Calif.	Gasoline Plant	.....	.....	Contracted	.....	.....	Ref. Maint.	Ref. Maint.
General Pet. Corp.	Torrance, Calif.	Vacuum Flash Tower	32,000 bbls.	$571,000	Contracted	Nov., '48	.....	Braun	Braun
Hancock Chem. Co.	Watson, Calif.	Elemental Sulfur Plant	50 tons	$1 million	Engineering being completed	Nov., 1948	.....	Badger	Badger
*The Paraffine Cos.	Emeryville, Cal.	Expand Asphalt Unit	1500 bbls.	$150,000	Under Constr.	Oct., 1948	.....	L. A. Rosener	.....
Robt. S. Lytle, Opr.	Coalinga, Calif.	H_2S Removal Plant	33,000 mcf	$175,000	Engineering in Course	1 year	Fluor	Fluor	Fluor
Shell Chemical Corp	Martinez, Calif.	Pet. Additives Plant	.....	.....	Under Constr.	Sept., 1948	.....	Parsons	Parsons
Shell Chemical Corp	Martinez, Calif.	Di-iso-butylene Unit	.....	.....	Completed	.....	.....	Staff	Staff
Shell Chemical Corp	Pittsburg, Calif.	Add Ammonia Plant	225% of prewar	.....	Under Constr.	Nov., 1948	.....	Bechtel Corp.	Bechtel Corp.
Shell Chemical Corp	Pittsburg, Calif.	Add Ammonium Sulfate Plant	180% of prewar	.....	Under Constr.	Aug., 1948	.....	Bechtel Corp.	Bechtel Corp.
Shell Oil Co.	Ventura, Calif.	Gasoline Plant	.....	.....	Under Constr.	.....	.....	Staff	Ref. Maint.
Standard Oil Co., of Calif.	Bakersfield, Calif.	Crude Dist, Cat Cracking	10,000 bbls.	$7.5 million	Announced	Mid '49	Braun	Braun	Braun
Standard Oil Co. of Calif.	Bakersfield, Calif.	Thermal, Crk., Gaso. Stabil., Gaso. Treating	9,000 bbls.	.....	Contracted	.....	U.O.P.	U.O.P.	Braun
Standard Oil Co. of Calif.	El Segundo, Cal.	Filling Plant Modernisation	.....	$2 million	Under Constr.	Dec. '48	.....	.....	.....
Standard Oil Co. of Calif.	Richmond, (California)	Grease, Wax Plant, Dock Facilities	82,000 lbs.	$13 million	Under Constr.	Sept. '48	U.O.P.	W. G. Peugh	Barrett & Hilp, Swinerton & Walberg & Bee C.Gerwick, Inc. Humiston-Rosendahl, Inc.
*Standard Oil Co. of Calif.	El Segundo, Cal.	Cracked Naphtha Rerun Stills	22,000 bbls.	$2.6 million	Contract let	Aug., 1949	.....	Braun	Braun
Standard Oil Co. of California	Richmond, Calif.	TCC Clay Repurification Unit	50 tons	$250,000	Under Constr.	Sept., 1948	Max B. Miller	Max B. Miller	Humiston-Rosendahl, Inc.
Union Oil Co. of California	Oleum, Calif.	Revision of Refining Facilities	.....	$4 2. million	Engineering	1949	.....	R. H. Parsons Co.	Ref. Maint.

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Union Oil Co. of California	Oleum, Calif.	Revision of Lube Dewaxing Facilities	1,000 bbls.	$1.7 million	Contracted	1949	Union Oil Co.	Kellogg	Kellogg
Union Oil Co. of California	Oleum, Calif.	Improvement to Compound & Grease Facilities	.....	$1.2 million	Engineering	1949	.....	J. M. Montgomery & Co.	.....
Union Oil Co. of California	Oleum, Calif.	Duo-Sol Unit	6,000 bbls.	$2.9 million	Contracted	1949	Max Miller	Max Miller	Max Miller
Union Oil Co. of California	Willmington, Calif.	Ethylene Production	100,000 lbs.	$2.5 million	Engineering	1949	Union Oil Co.	Foster-Wheeler	.....
Union Oil Co. of California	Willmington, Calif.	H_2S Recovery	30,000 lbs.	$200,000	Engineering	1949	None	Ehrhart & Arthur, Inc.	
FOREIGN									
A. I. O. C.	Abadan	Gas Plant	25,000 mcf	$2 million	Under Constr.	.....	.....	Badger	Badger
Agwi Pet. Corp.	Fawley, Eng.	.....	120,000 bbls.	$140 million	Projected	1952	.....	.....	.....
Anglo-Iranian Oil Co.	Abadan, Persian Gulf	Cat. Cracker	30,000 bbls.	.....	Planned	.....	.....	.....	.....
Anglo-Iranian Oil Co.	Adadan, Persian Gulf	Lube Plant	400 bbls.	.....	Planned	.....	Texaco	Badger	Staff
*Azienda Generale Italiana Petroli	Rome, Italy	Add to Plant	24,000 bbls.	.....	Projected	.....	.....	.....	.....
Bahrein Pet. Co., Ltd.	Bahrein Island	Expansion Program	.....	$8.9 million	Under Constr.	June, 1949	.....	U.O.P., Bechtel	International, Bechtel, Inc.
Bataafsche Petroleum Maatschappij	Rotterdam-Pernis	.....	60,000 bbls	.....	.....	.....	.....	.....	.....
British-American Oil Co., Ltd.	Montreal East, P.Q.	Cat Craking and Cat. Poly.	13,300 bbls.	.....	Under Constr	Late 1949	Kellogg-U.O.P.	Kellogg	Kellogg
British Pet. Chem., Ltd.	Gangemouth, Scotland	Petro-chem	.....	$20 million	Planned	.....	.....	S & W, Badger	S & W, Badger
Burmah Oil Co.	Burma	Furfural Plant	1,000 bbls.	$600,000	Planned	.....	Texaco	Badger	.....
Burmah Oil Co.	Syriam, Burma	Thermafor Clay Revivification	66 tons	$150,000	Design	1949	Max Miller, Socony-Vacuum	Max Miller	.....
Caltex Pet. Maatschappij, N.V.	Rotterdam, Holland	Crude Plant	20,000 bbls.	$18 million	Projected	Early '50	.....	McKee	McKee
Caltex Maatschap	Rotterdam	SO_2 Plant	1,800 bbls.	$600,000	Planned	.....	.....	Badger	.....
Consolidated Ref., Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.	.....	Planned	By 1950	.....	Badger	Badger
Consolidated Ref., Ltd.	Haifa	General Facilities	.....	.....	Under Design	.....	.....	Badger, Ltd.	.....
Consolidated Ref. Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Planned	.....	Texaco, Juik	Lummus Kellogg	Badger
Creole Pet. Corp.	Amuay Bay, Venezuela	Cat Cracking	60,000 bbls.	$70 million	Under Constr.	1950	.....	.....	.....
Creole Pet. Corp.	Molata Field, Venezuela	Stabilization and Repressuring Plants	.....	.....	.....	.....	.....	.....	.....
Creole Pet. Corp.	El Roble Field, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
Egyptian Government	Egypt	Crude Plant	.....	.....	.....	.....	.....	Lummus	Lummus
Imperial Oil, Ltd.	Montreal, East, Canada	Crude Pipe, Still, Cat Cracker, Cat Poly	33,000 bbls.	$22 million	Under Constr.	Summer '48	.....	S.O.D., Kellogg	Kellogg
Imperial Oil, Ltd.	Edmonton, Canada	Thermal, Crack, Crude Dist.	6,000 bbls.	$8.7 million	Under Constr.	Late 1948	.....	Barnes, Impl. Oil	Barnes
Imperial Oil, Ltd.	Leduc Field	Gas Absorption Plant	.....	$1.5 million	Projected	.....	.....	.....	.....
Industrie Chimiche Italiane Petroli	Mantau, Italy	Crude	4,500 bbls.	.....	.....	.....	.....	.....	.....
Kuwait Oil Co.	Kuwait	Topping Unit	20,000 bbls.	$2 million	Planned	.....	.....	Badger	Badger
McColl-Frontenac Oil Co., Ltd.	Montreal, East Que., Canada	Fluid Cat. & Cat. Poly.	40,000 bbls.	.....	Under Constr.	Mid 1948	.....	Kellogg	Kellogg
Mediterranean Ref. Co.	Sidon, Lebanon	SO_2 Extraction Plant	18,000 bbls	.....	Contracted	Sept., 1949	.....	Badger	.....
Mediterranean Ref. Co.	Trans-Arabian P. L. Mediterranean Terminal	Refinery	.....	.....	"Paper stage"	.....	.....	.....	.....
Mene Grande	West Guara, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
National Oil Refineries, Ltd.	Llandarcy Wales	Crude & Reform.	20,000 bbls.	$36 million	Contracted	.....	.....	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	Lubes & Wax	1,200 bbls.		Contracted	.....	.....	Badger	Badger
Petro Carbon, Ltd.	Partington, England	Cat Cracker, Lube & Reform	20,000 bbls.	.....	.....	.....	.....	.....	.....
Petro Chem., Ltd.	Partington, England	Petro Chemicals	.....	.....	.....	.....	.....	.....	.....
Petróleos Mexicanos	Ciudad Madero	Crude Unit	25,000 bbls.	$2 million	Under Constr.	July, 1948	None	Staff	Staff
Petróleos Mexicanos	Poza Rica, Mex.	Gas Purification, Pressure Maintenance, etc.	.....	$13 million	Contracted	Early 1950	.....	McKee	McKee
Petróleos Mexicanos	Salamanca, Mex.	Crude, Gasoil, Cracking	30,000 bbls.	$12 million	Contract let	1949	U.O.P.	McKee	McKee
Porto Marghera Rfg.	Venice, Italy	Enlarging	.....	.....	.....	.....	.....	.....	.....
Raffineries de Pétrole de la Gironde	Ambes, France	Crude Plant	14,000 bbls.	$7.5 million	Under Constr.	Early 1950	.....	U.O.P., McKee	McKee
Scottish Oils, Ltd.	Grangemouth, Scotland	Crude	24,000 bbls.	$28 million	Planned	.....	.....	.....	.....
Scottish Oils, Ltd.	Grangemouth, Scotland	Cat Crk.	5,000 bbls.		Planned	.....	.....	.....	.....
Shell Chemical Corp.	Thornton, Eng.	Petro-chem	.....	Several millions	Under Constr.	.....	.....	.....	.....
Shell Chemical Corp.	Shell Haven, England	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Chemical Corp.	Stanlow, Eng.	Petro-chem	.....	.....	.....	.....	.....	.....	.....
*Shell Oil Co. of British Columbia	Shellburn Ref., Vancouver	Add Crude Distillation	7500 bbls.	$600,000	Under Constr.	Feb., 1949	.....	Staff	Staff
Shell Oil Co. (Venezuela)	Cardón, Venezuela	Complete Refg.	.....	.....	Under Constr.	.....	.....	Lummus	Lummus
Shell Oil Co.	Heysham, Eng.	Remodel & Redesign Crude Plant	30,000 bbls.	.....	Under Constr.	Mid '48	.....	.....	.....
Société General des Huiles de Pétrole	Dunkirk, France	Crude Reform.	26,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
Société General des Huiles de Pétrole	Courchelettes, France	Lube & Wax	800 bbls.	.....	Under Constr.	.....	.....	.....	.....
Stora Kopparberg	Sweden	Crude, Ther. Cracking	.....	.....	.....	.....	.....	Lummus	Lummus

Table Concluded on Page 140

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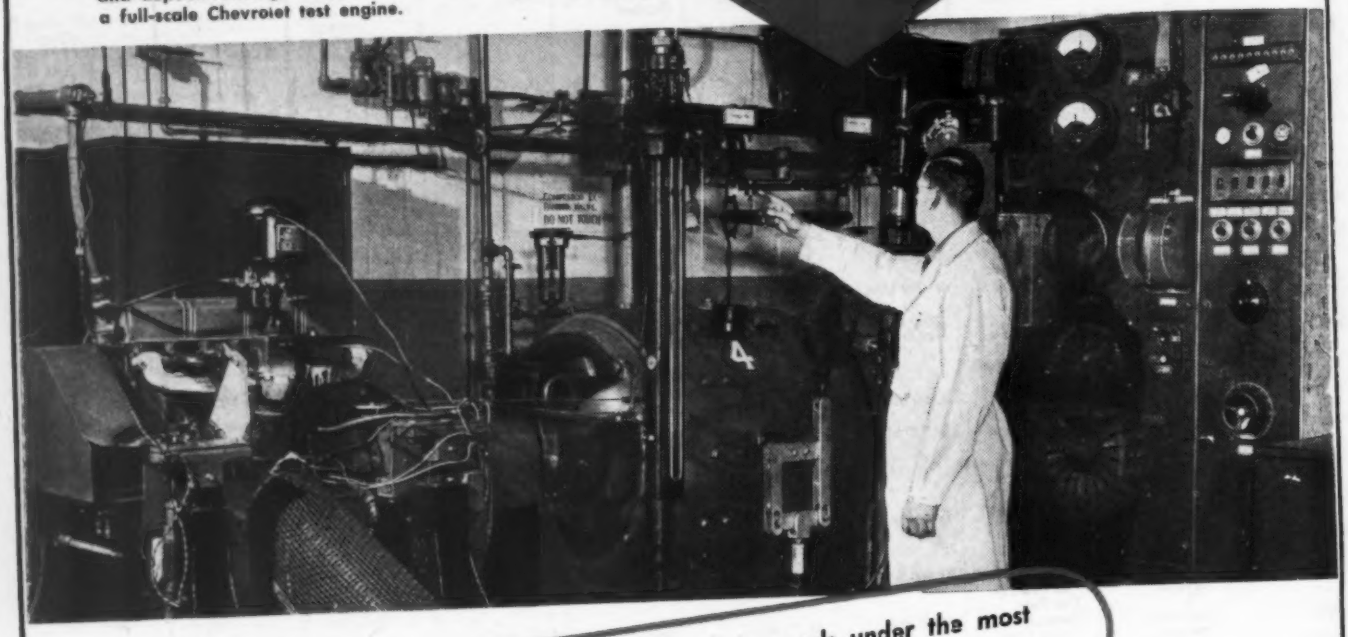

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PARAPOID —*for E.P. gear oils.*
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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4 to $8 million	Plans approved	.....	.....	.....	.....
Venezuelan Pet. Co., (Sinclair)	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.	.....	Clearing site	.....	.....	.....	.....
Yacimientos Petroliferos, Fiscales	La Plata Argentina	Crude Topping, Gaso Treating	50,000 bbls.	$2.8 million	Under Constr.	Early 1949	.....	Houdry Process Cat. Constr.	Cat. Constr.
Yacimientos Petroliferos Fiscales Bolivianos	Sucre, Bolivia	Crude Plant	3,000 bbls.	.....	.....	1950	.....	Foster-Wheeler	Foster-Wheeler
Yacimientos Petroliferos Fiscales Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.	.....	.....	1949	.....	Foster-Wheeler	Foster-Wheeler
YPF Brazil.....	Santos, Brazil	Complete Refg.	20,000 bbls.	$30 million	Projected	.....	.....	.....	.....

* First appearance in tabulation. † Added capacity.

NOTE—Ampco—Ampco Engineering Co. Badger—E. B. Badger and Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Bros., McCone Co. Bellows—W. S. Bellows Co. Braun—C. F Braun Co. Cat. Constr.—Catalytic Construction Co. Chem. Constr.—Chemical Construction Co. Clark's—Clark's Construction and Engineering Co. Dresser—Dresser Engineering Corp. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Gaso. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. Hydro Res.—Hydrocarbon Research, Inc. J & L Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch Eng.—Koch Engineering Co. Koppers—Koppers Co., Inc. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Co. McKee—Arthur G. McKee Co. Mid-Continent—Mid-Continent Engineering Co. Max Miller—Max B. Miller & Co. Parsons—Ralph M. Parsons Co. Pet. Eng.—Petroleum Engineering, Inc. Pritchard—J. F. Pritchard Co. Process Eng.—Process Engineers, Inc. Ref. Eng.—Refinery Engineering Co. Ref. Maint.—Refinery Maintenance Co., Inc. Standard Oil Development Co. Stearns-Roger Manufacturing Co. Tellepsen—Tellepsen Construction Co. Texaco—Texaco Development Co. U.O.P.—Universal Oil Products Co. Walco—Walco Engineering. Wohfeld—Wohfeld Construction Co. ‡ Equally owned by California Texas Corp. and Socony-Vacuum Oil Co., Inc.

Indiana Standard Buys Future Expansion Tract

Standard Oil Company (Indiana) last month announced purchase of 960 acres comprising the former Jones and Laughlin Steel Corporation property in Hammond, Ind. Standard acquired the property for future expansion but said no specific plans have yet been developed. The tract is south of Standards new research laboratory and adjacent to the company's Whiting, Ind., refinery.

Jones and Laughlin disposed of the property "because of the exorbitant cost of building entirely new steel plants from the ground up". That company believes it is more economical to expand its present facilities and has already appropriated $117 million as the first step in a major improvement and expansion program at other locations. Work on this phase of the program began in 1946 and will not be entirely completed until 1950.

Sun Starts Building

Sun Oil Company has started construction on a plant near Jameson Field in Coke County, Texas with work expected to be completed by March 1. A pressure maintenance plant primarily, the plant will also have hydrocarbon recovery facilities. Capacity will be 10 million cubic feet per day, and production will be 30,000 gallons per day of liquid hydrocarbons.

The Delhi Plant, which Sun is building for itself and 15 other Louisiana producers, will officially open soon.

Construction is due to start immediately on Sun's Starr County plant, near Sun Field in Southwest, Texas.

Texaco Research Expands

The Texas Company is planning to construct three new buildings at its Beacon, N. Y. research laboratories as part of its 10-year research expansion program. The buildings to be completed next year will increase facilities at Beacon by 40 percent.

In the engineering building will be laboratories for volatility, lubrication and combustion studies and the chemistry building will have 18 laboratories for the development of new lubricants. Office space and required services for activities for the other units will be provided for in the third building.

Cosden Plans To Rebuild Catalytic Cracking Unit

Rebuilding of the cracking plant partly destroyed by fire in May, 1947, was authorized last month at the annual meeting of the directors of Cosden Petroleum Corporation, Big Spring, Texas.

In rebuilding, the cracking plant will be changed from thermal to fluid catalytic cracking and will be operated under license from Universal Oil Products Company, Chicago, according to R. L. Tollett, president.

New Refinery for England

Anglo-Iranian Oil Company and Gulf Oil Company jointly are planning to construct a refinery on the Isle of Grain at the Thames and Kedway estuaries. Construction date has not been set, but the cost is estimated in excess of $120 million.

The central refinery unit will be built first. Following this unit will be the cracking and related units. Ultimate daily capacity will be 83,288 barrels.

Edgington Plant Finished

Completion of a 2000 barrel daily capacity asphalt oxidizing plant at the Edgington Oil Refinery at Long Beach, Calif., has been announced by David W. Jones, general manager.

The plant was engineered by the Edgington engineering staff and constructed at a cost of approximately $80,000.

New Standard Tankers

Eight super-tankers, at a cost of more than $75 million, will be added to Standard Oil Company's (New Jersey) ocean-going vessels. This group brings the total of such vessels—each of 228,000-barrel capacity—being built by the company to 14. One is scheduled for delivery by the end of this year, five by 1949 and the rest by 1950.

Ground Broken for Sohio's Enlarged Plant at Lima

Ground was broken August 2 for the new catalytic cracking unit at the Lima refinery of Standard Oil Company (Ohio). When it is completed in about 15 months, the plant is expected to produce 30 percent more gasoline per barrel of crude oil and will run 16,000 barrels per day.

The first unit of the $16 million Sohio expansion and modernization program at the refinery, the fluid catalytic cracking plant will double the refinery's capacity. Besides the $11 million cracking plant with its gas plant, water-cooling tower, gasoline treating and blending facilities and 20-million gallon additions to the tankage facilities, a $5 million oil refining unit, a combination crude oil distillation and coking plant which will add 15,000 barrels daily to the crude oil processing capacity of the Lima plant, will be added.

Stanolind Planning Huge Research Unit Expansion

Stanolind Oil and Gas Company will begin construction of a new and larger research center at Tulsa the latter part of this year, the new plant to be ready for use early in 1950. Present research buildings in Tulsa will be used primarily for the manufacture of field geophysical equipment and for testing and analytical work.

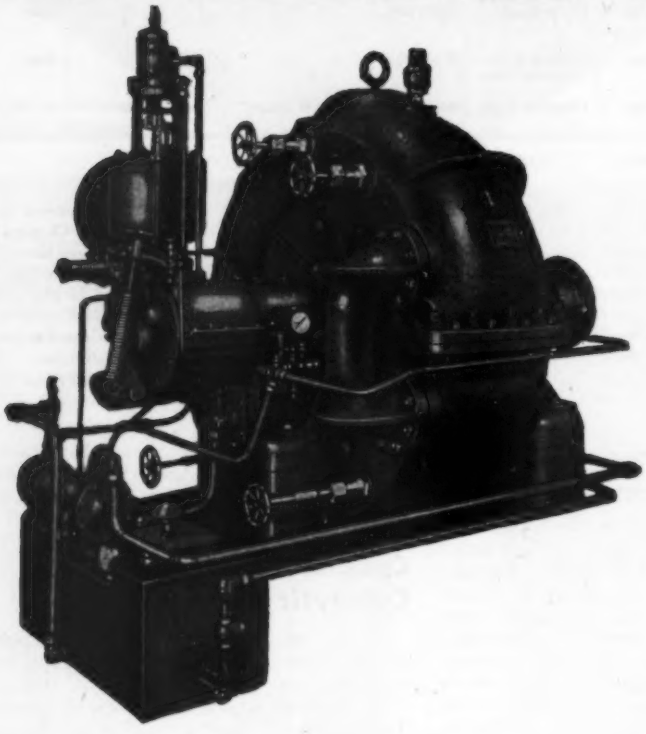
Seven hundred people will be employed in the new buildings as compared with 100 presently employed.

Imperial May Enlarge

A $2,500,000 expansion of its $8.7 million Edmonton, Alberta, refinery is being considered by Imperial Oil, Ltd. The plant's capacity would be increased to 11,000 barrels of crude oil daily.

Although now officially open, the refinery is expected to reach its full production of 6000 barrels a day from Leduc field by the end of the year. The current rate is about 4000 barrels daily. Work is being speeded on incomplete units so as to be ready soon for capacity output.

TERRY



THE WHEEL OF THIS 165 lb. BACK PRESSURE TURBINE IS DOUBLE RIM PROTECTED

The 925 H. P. Back Pressure Turbine shown above employs a Terry Solid Wheel Rotor as shown at the left.

The buckets are protected by rims at the sides of the wheel. These rims would take without damage any rubbing that might occur if the clearance became reduced.

With this construction it is impossible for the blades to foul and frequent inspections of the thrust bearings are not required to obtain safe and dependable operation.

The Terry Wheel Turbine is fully described in our Bulletin T-1165. A request on your business letterhead will bring a copy.

T-1165

THE TERRY STEAM TURBINE COMPANY
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7.2% Increased Demand Met

During First Half of 1948

L. J. LOGAN, Economics Editor

In the first half of 1948 the petroleum industry of the U. S. proved able to meet more demand for its products than government and industry economists thought possible. It supplied a total demand for all oils in the amount of 1,127,272,000 barrels, an average of 6,194,000 barrels daily, which was 7.2 percent more than the 5,779,000 barrels per day of demand in the initial half of 1947.

For the whole year of 1948 approximately this same increase in total demand now is forecast by the U. S. Bureau of Mines in a second revision of its original estimates. The bureau now estimates for 1948 a total demand for 2316 million barrels of all oils, an average of 6,328,000 barrels daily, which would be 428,000 barrels a day or 7.3 percent more than the 5,900,000 barrels daily of actual demand in 1947. This estimate was embodied in the revised forecast for 1948, published by the agency along with its monthly petroleum forecast for July.

Refined Stocks Up

In addition to supplying a 7.2 percent increase in demand in the first half of this year, the industry made a substantial and needed increase in stocks of refined products, adding about 15 million barrels or an average of 86,000 barrels daily. These stocks will help to supply the further increase in demand which is expected for the latter half of the year. Requirements are foreseen as rising to 6,674,000 barrels daily in the fourth quarter of 1948, when fuel oils will have to come from storage to meet seasonal demand.

The building up of stocks in the first half of 1948 was in contrast with results in the initial half of 1947, when stocks were reduced over 10 million barrels or 58,000 barrels daily.

By virtue of the accumulation of inventories in the first half of this year, it will be possible to continue meeting demand more than 7 percent higher than last year by only moderately increasing crude oil production and refinery runs in the third and fourth quarters, Bureau of Mines forecast data indicate. In arriving at the estimate that daily average demand for the year as a whole would be 7.3 percent larger than in 1947, the bureau estimated that crude runs to stills would increase from 5,372,000 barrels daily in the first quarter of 1948, to 5,600,000 barrels daily in the second quarter, 5,660,000 daily in the third quarter, and 5,680,000 daily in the fourth quarter, to give an average of 5,578,000 daily for the year as a whole. That would be 503,000 barrels daily or 9.9 percent more than the actual runs of 5,075,000 barrels per day in 1947. Crude oil production was estimated as rising from 5,347,000 barrels daily in the first quarter to 5,500,000 daily in the second quarter, to 5,610,000 daily in the third quarter, and then to 5,621,000 daily in the fourth quarter.

While the industry supplied 7.2 percent more oils per day in the first half of 1948 than in the like period of 1947, it supplied an even larger increase for domestic consumption by virtue of cutting down exports. Domestic demand supplied averaged 5,828,000 barrels daily, an increase of 501,000 barrels daily or 9.4 percent over the 5,327,000 daily of domestic demand in the first half of last year. For the remainder of this year similar results are expected. The Bureau of Mines estimates a daily average domestic demand of 5,934,000 barrels daily, an increase of 485,000 barrels per day or 8.9 percent over the 5,449,000 daily of 1947. Exports averaged 366,000 barrels daily in the first half of 1948, down 86,000 barrels or 19 percent from the

Latest Revised Forecast of United States Supply and Demand, All Oils, 1948 by Quarters, and Actual for 1947

Source: U. S. Bureau of Mines' Monthly Petroleum Forecast, July, 1948

(THOUSANDS OF BARRELS)

ITEM	First Quarter 1948	Second Quarter 1948	Third Quarter 1948	Fourth Quarter 1948	1948 Year (Forecast)	1947 Year (Actual)	Percent Change '47-'48
PRODUCTION							
All Oils	522,300	537,000	554,000	555,500	2,168,800	1,988,797	+ 9.1
(Daily Average)	5,740	5,901	6,022	6,038	5,926	5,449	+ 8.8
Crude Oil	486,600	500,500	516,100	517,100	2,020,300	1,856,107	+ 8.8
(Daily Average)	5,347	5,500	5,610	5,621	5,520	5,085	+ 8.6
Other Oils	35,700	36,500	37,900	38,400	148,500	132,690	+11.9
(Daily Average)	293	401	412	417	406	364	+11.5
IMPORTS							
All Oils	43,200	44,300	46,500	48,000	182,000	159,595	+14.0
(Daily Average)	475	487	505	522	497	437	+13.7
Crude Oil	25,500	28,000	30,000	30,000	113,500	97,532	+16.4
(Daily Average)	280	308	326	326	310	267	+16.1
Other Oils	17,700	16,300	16,500	18,000	68,500	62,063	+10.4
(Daily Average)	195	179	179	196	187	170	+10.0
NEW SUPPLY							
All Oils	565,500	581,300	600,500	603,500	2,350,800	2,148,392	+ 9.4
(Daily Average)	6,214	6,388	6,527	6,560	6,423	5,886	+ 9.1
STOCK CHANGE							
All Oils	−9,300	+24,100	+30,500	−10,500	+34,800	−5,041	.....
Daily Average)	−102	+265	+331	−114	+95	−14	.....
Crude Oil	+3,500	−4,300	+200	+2,100	+1,500	+478	.....
(Daily Average)	+38	−47	+2	+23	+4	+1	.....
Other Oils	−12,800	+28,400	+30,300	−12,600	+33,300	−5,519	.....
(Daily Average)	−140	+312	+329	−137	+91	−15	.....
DEMAND							
All Oils, Total Demand	574,800	557,200	570,000	614,000	2,316,000	2,153,433	+ 7.5
(Daily Average)	6,316	6,123	6,196	6,674	6,328	5,900	+ 7.3
Domestic Demand	546,700	518,300	526,000	581,000	2,172,000	1,988,970	+ 9.2
(Daily Average)	6,007	5,696	5,718	6,315	5,934	5,449	+ 8.9
Exports	28,100	38,900	44,000	33,000	144,000	164,463	−12.4
(Daily Average)	309	427	478	359	394	451	−12.9
Crude Oil Exports	8,800	11,200	13,000	10,000	43,000	46,117	− 6.8
(Daily Average)	97	123	141	109	118	127	− 7.1
Refined Oil Exports	19,300	27,700	31,000	23,000	101,000	118,346	−14.7
(Daily Average)	212	304	337	250	276	324	−14.8
Motor Fuel, Total Demand	192,600	241,400	250,000	229,000	913,000	842,352	+ 8.4
(Daily Average)	2,116	2,653	2,717	2,489	2,495	2,308	+ 8.1
Domestic Demand	185,900	230,100	239,000	221,000	876,000	794,807	+10.2
(Daily Average)	2,043	2,529	2,598	2,402	2,394	2,178	+ 9.9
Exports	6,700	11,300	11,000	8,000	37,000	47,545	−22.2
(Daily Average)	73	124	119	87	101	130	−22.3
Residual Fuel, Total Demand	144,100	127,900	124,500	142,000	538,500	529,139	+ 1.8
(Daily Average)	1,584	1,405	1,353	1,544	1,471	1,450	+ 1.4
Domestic Demand	142,200	124,800	121,500	140,000	528,500	518,394	+ 1.9
(Daily Average)	1,563	1,371	1,320	1,522	1,444	1,420	+ 1.7
Exports	1,900	3,100	3,000	2,000	10,000	10,745	− 6.9
(Daily Average)	21	34	33	22	27	30	−10.0
Distillate Fuel, Total Demand	119,500	78,500	71,500	113,000	382,500	328,150	+16.6
(Daily Average)	1,313	863	777	1,228	1,045	899	+16.2
Domestic Demand	114,500	71,500	63,000	108,000	357,000	298,221	+19.7
(Daily Average)	1,258	786	685	1,174	975	817	+19.3
Exports	5,000	7,000	8,500	5,000	25,500	29,929	−14.8
(Daily Average)	55	77	92	54	70	82	−14.6
Kerosine, Total Demand	40,400	21,600	22,500	38,500	123,000	109,771	+12.1
(Daily Average)	444	237	245	409	336	301	+11.6
Domestic Demand	39,700	20,800	20,500	36,500	117,500	102,507	+14.6
(Daily Average)	436	228	223	397	321	281	+14.2
Exports	700	800	2,000	2,000	5,500	7,264	−24.3
(Daily Average)	8	9	22	22	15	20	−25.0
All Other Oils, Total Demand	78,200	87,800	101,500	91,500	359,000	344,021	+ 4.4
(Daily Average)	859	965	1,103	995	981	943	+ 4.0
Domestic Demand	64,400	71,100	82,000	75,500	293,000	275,041	+ 6.5
(Daily Average)	708	781	891	821	801	754	+ 6.2
Exports	13,800	16,700	19,500	16,000	66,000	68,980	− 4.3
(Daily Average)	151	184	212	174	180	189	− 4.8
CRUDE NEEDED							
Runs to Stills	488,850	509,600	520,700	522,550	2,041,700	1,852,246	+10.2
(Daily Average)	5,372	5,600	5,660	5,680	5,578	5,075	+ 9.9
Demand for Domestic Crude	483,900	505,050	516,100	515,200	2,020,250	1,855,599	+ 8.9
(Daily Average)	5,318	5,550	5,610	5,600	5,520	5,084	+ 8.6

New Refining Records

Refinery operations in the U. S. have been at remarkably high levels in the first half of this year, setting new all-time records. Instead of offering any excuses for scarcities of oils, the industry is well justified in claiming credit for a near-impossible achievement in boosting refinery throughput to the high levels that have been maintained.

452,000 daily in the like period last year. The Bureau of Mines estimates for 1948 as a whole exports averaging 394,000 barrels daily, down 57,000 daily or 12.9 percent from the 451,000 daily exported in 1947.

Additions to stocks are expected to continue in relatively large volume in the third quarter, after which seasonal withdrawals will take place in the fourth quarter. For 1948 as a whole a net increase of nearly 35 million barrels or an average of 95,000 barrels daily is forecast. This would contrast with a net reduction of about 5 million barrels or 14,000 barrels daily in 1947. This indicated increase in inventories this year, in the face of meeting sharply higher demand, is a noteworthy achievement.

U. S. imports of all oils averaged 481,000 barrels daily in the first half of 1948, an increase of 26,000 barrels daily or 5.7 percent over the 455,000 daily imported in the initial half of 1947. The Bureau of Mines estimates that total imports in 1948 will average 497,000 barrels daily, up 60,000 from the 437,000 daily in 1947. In the third and fourth quarters some stepping up of imports is expected. For the first half of this year the imports of 481,000 barrels daily exceeded exports of 366,000 daily by 115,000 barrels per day. For the whole year 1948 the estimated imports of 497,000 barrels daily would be 103,000 per day more than the anticipated exports of 394,000 daily.

In the first six months of 1948, crude runs to stills averaged 5,490,000 barrels per day, an increase of 627,000 barrels or 12.9 percent over the runs of 4,863,000 barrels per day in the initial half of 1947. The runs this year have been 1,796,000 barrels daily or virtually one half again as great as in the first half of 1941, last prewar year for the United States, when they averaged 3,694,000 daily.

Billion Near Miss

Total volume of crude oil charged to stills in the first half of this year was barely short of a billion barrels. It amounted to 999,173,000 barrels, or 13.5 percent more than the 880,132,000 barrels run in the same period last year. Runs in the first half of 1941 totaled 668,663,000 barrels. All refining districts have processed more crude this year than last year.

In June refinery runs continued to show large increases over last year. For the nation runs averaged 5,644,000 barrels daily. That was considerably more than the daily average of 5,490,000 daily for the first six months. It was 524,000 barrels per day more than the runs of 5,120,000 barrels daily in the first half of 1947 and was 1,788,000 barrels a day or nearly 50 percent more than the runs of 3,856,000 daily in June, 1941.

In achieving the high refinery runs of this year, the industry has had the benefit of some increase since a year ago in refining capacity. But the principal means by which plant throughput has been increased has been that of pushing actual runs very close to full rated capacity. Virtually all facilities that can be operated are being utilized, including some units that normally would be closed down because of being obsolete or inefficient. All facilities are being operated with a minimum of timeout for repairs and maintenance. Many units are being operated in excess of their rated capacity, with benefit of comparatively new equipment. Several whole districts have been maintaining runs at more than 100 percent of rated capacity, including particularly the East Coast district, the Texas Gulf Coast, and the Louisiana Gulf Coast.

In June the indicated refining capacity in use in the U. S. totaled 5,830,000 barrels daily, from which actual runs of 5,644,000 barrels per day were achieved, indicating an average operating rate of 96.7 percent. In achieving this average, runs went as high as 97 or 98 percent of capacity in individual weeks of June, and more recently they have gone above 99 percent.

The 5,838,000 barrels per day of capacity available in June was 225,000 barrels more than the 5,613,000 barrels available in June of last year, most of the refining districts having gained additional capacity.

However, the plants of a year ago were operating at only 91.2 percent of capacity in June. The present capacity is 1,303,000 barrels per day more than that of 4,535,000 barrels daily available in June, 1941, when plants were operated at 85.2 percent of capacity.

While the nation as a whole was operating plants at 96.7 percent of capacity in June of this year, Louisiana Gulf Coast refineries operated at 116.2 percent, East Coast plants at 108.1 percent, and Texas Gulf Coast plants at 105.0 percent. Close to the national average were Oklahoma-Kansas-Missouri plants, operating at 95.8 percent of capacity. Illinois-Indiana-Kentucky plants operated at 92.6 percent, Rocky Mountain plants at 87.9 percent, and California refineries at 84.4 percent.

U. S. Crude Runs to Stills and Percent of Refinery Capacity Used, by Districts, June and First 6 Months 1941, 1947, 1948
Runs from Bureau of Mines, except May and June, 1948, from American Petroleum Institute. Capacities from American Petroleum Institute
(THOUSANDS OF BARRELS)

REFINING DISTRICT	CRUDE RUNS IN JUNE: Total Amount Run				CRUDE RUNS IN JUNE: Daily Average Run			REFINING CAPACITY IN USE, JUNE: Daily Capacity			REFINING CAPACITY IN USE, JUNE: Percent Capacity Used			TOTAL AMOUNT OF CRUDE RUN TO STILLS, FIRST 6 MONTHS			
	June, 1941	June, 1947	June, 1948	% Dif. '47-'48	June, 1941	June, 1947	June, 1948	June, 1941	June, 1947	June, 1948	June, 1941	June, 1947	June, 1948	Jan.-June, 1941	Jan.-June, 1947	Jan.-June, 1948	% Dif. '47-'48
East Coast	16,955	26,137	26,906	+ 2.9	565	871	897	643	816	830	87.9	106.7	108.1	101,988	144,144	156,109	+ 8.3
Appalachian	4,491	5,025	5,061	+ 0.7	150	168	169	156	195	191	96.2	86.2	88.5	25,924	30,067	30,820	+ 2.5
District No. 1	.....	2,878	3,253	+13.0	.....	96	109	.....	130	123	.....	73.8	88.6	.....	17,912	18,476	+ 3.1
District No. 2	.....	2,147	1,808	—15.8	.....	72	60	.....	65	68	.....	110.8	88.2	.....	12,155	12,344	+ 1.6
Indiana, Illinois, Kentucky	21,225	24,310	27,205	+11.9	707	810	907	743	922	980	95.2	87.9	92.6	118,707	144,326	159,080	+10.2
Oklahoma, Kansas, Missouri	10,831	12,735	13,626	+ 7.0	361	424	454	420	454	474	86.0	93.4	95.8	60,578	72,884	79,986	+ 9.7
Texas Inland	5,551	7,097	7,334	+ 3.3	185	237	244	280	296	297	66.1	80.1	82.2	32,102	39,392	44,727	+13.5
Texas Gulf Coast	28,482	35,625	42,466	+19.2	950	1,187	1,416	1,071	1,328	1,349	88.7	89.4	105.0	171,374	200,147	249,223	+24.6
Louisiana Gulf Coast	4,448	12,014	12,718	+ 5.9	148	401	424	164	357	365	90.2	112.3	116.2	24,859	66,127	77,264	+16.8
North Louisiana and Arkansas	2,124	2,029	2,618	+29.0	71	68	87	101	114	121	70.3	59.6	71.9	13,524	11,348	14,507	+27.8
Rocky Mountain	2,924	4,321	5,004	+15.8	97	144	167	121	187	190	80.2	77.0	87.9	15,805	24,942	29,120	+16.8
District No. 3	.....	362	350	— 3.3	.....	12	12	.....	13	15	.....	92.3	80.0	.....	1,772	2,163	+22.1
District No. 4	.....	3,959	4,654	+17.6	.....	132	155	.....	174	175	.....	75.9	88.6	.....	23,170	26,957	+16.3
California	18,904	24,311	26,370	+ 8.5	630	810	879	836	944	1,041	75.3	85.8	84.4	103,802	146,735	158,337	+ 7.9
Total United States	115,935	153,604	169,308	+10.2	3,865	5,120	5,644	4,535	5,613	5,838	85.2	91.2	96.7	668,663	880,132	999,173	+13.5

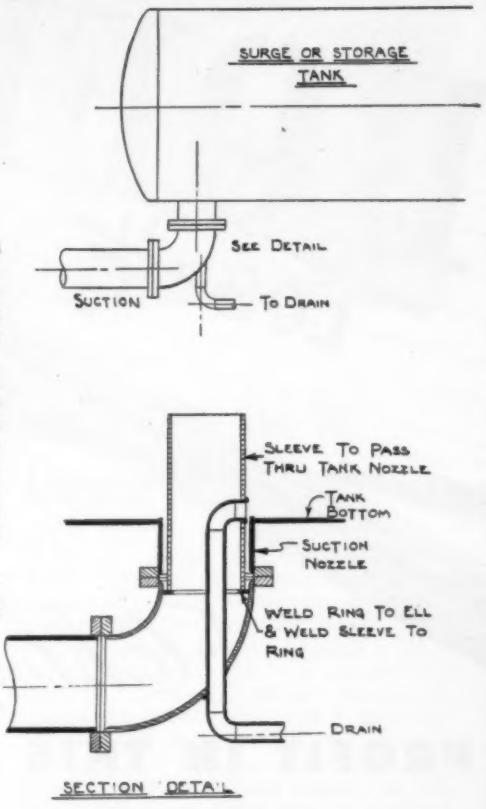
OPERATION HOW TO DO IT MAINTENANCE

HOW TO—
Install Sludge Trap In Surge or Storage Tank

THE accompanying drawing shows how a sludge trap may be installed in a surge or storage tank. The trap and drain can be fabricated in the plant shop and fitted into the tank as a complete unit.

A vessel which contains inflammable sludge material is very often difficult to render safe for entry or welding. The proposed trap and drain arrangement can be installed without the need for blinding and purging. The only preparation required is that the tank be taken out of service and drained for the short period of time involved.

(Contributed by L. J. Ronayne, process engineer, Plains Plant, Phillips Petroleum Company, Borger, Texas.)



HOW TO—
Provide Drinking Water During Turnarounds

A PORTABLE, electrically refrigerated water cooler has saved labor and time in providing the drinking water required for large maintenance crews employed in turnarounds and other cleanout operations at Pan American Refining Corporation's Texas City, Texas, refinery.

During a recent turnaround of a fluid catalytic cracking unit, it was found that drinking water kegs were filled 510 times and that 25,500 pounds of ice was used to cool 4080 gallons of water consumed during the two-week period. Thousands of paper cups were used. To keep an adequate supply of water required the full time of two men and a truck and driver part of the time.

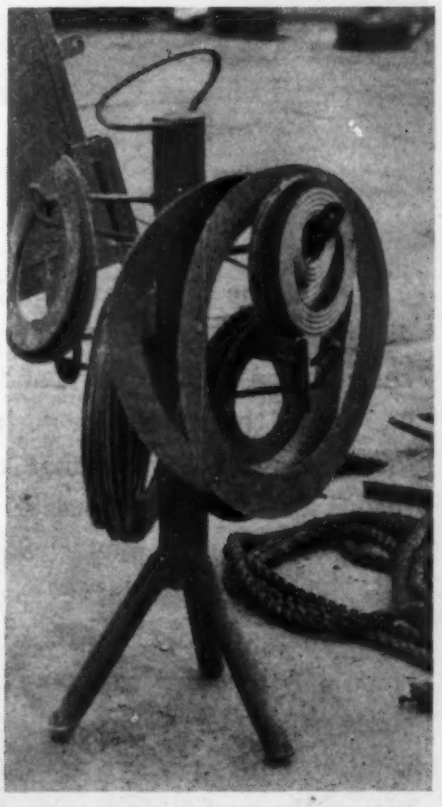
Water, drainage, and power connections for the portable cooler have been installed near areas where major maintenance operations are required. Six fountain outlets on the cooler can supply in excess of 300 gallons of cool water daily. The need for paper cups is eliminated, and the men and equipment previously used are released for other duties.

While the initial investment for the cooler is comparatively high, it is estimated to pay for itself in less than a year.

HOW—
Handy Gasket Rack Saves Heading-Up Time

A handy rack for carrying an assortment of gaskets to the job site can save considerable time in heading up towers and other similar equipment. A variety of gaskets can be carried on the rack, thus eliminating trips to the central gasket board or warehouse. The gaskets are not likely to become damaged on the rack.

The rack consists of an upright standard with a tripod base. Several arms for hanging the gaskets are welded to the standard. A handle is provided for carrying and to facilitate hoisting the rack to above grade working platforms.



HOW—
Device Becomes Real Welder's Helper

A VERSATILE, mechanical "welder's helper" which rotates the article or equipment being welded at any rate convenient to the welder, has been devised and fabricated in one refinery shop.

The machine consists of an air-driven

Chlorination

PUTS THE PROFIT IN THIS EQUATION

The log mean terminal temperature difference goes down and stays that way when chlorination goes to work and stops slime formation on the water-side surfaces of your condensers and heat exchange equipment. This means lower fuel costs, less out-of-service time, the elimination of plug cleaning, more profit.

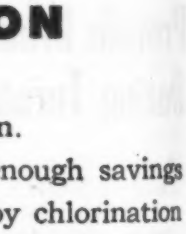
Since even the slightest slime film means a high LMTTD, it is important that the remedy get at the basic cause of the trouble—slime forming organisms. That's just what chlorination does and here are some typical examples of the profitable results:

A southern power station realized a net annual saving in steam costs alone of $16,000 from a W&T installation.

A refinery obtained enough savings through condenser de-sliming by chlorination to pay the cost of the installation in six months.

A midwestern power company obtained savings of $11,000 in one year through cooling water chlorination.

Call your nearest W&T Representative, backed by over thirty years' experience in water treatment, for a cooling water study of your plant—there's no obligation, of course. and you may find, as so many other plants have, that the LMTTD isn't as low as it could be with chlorination.



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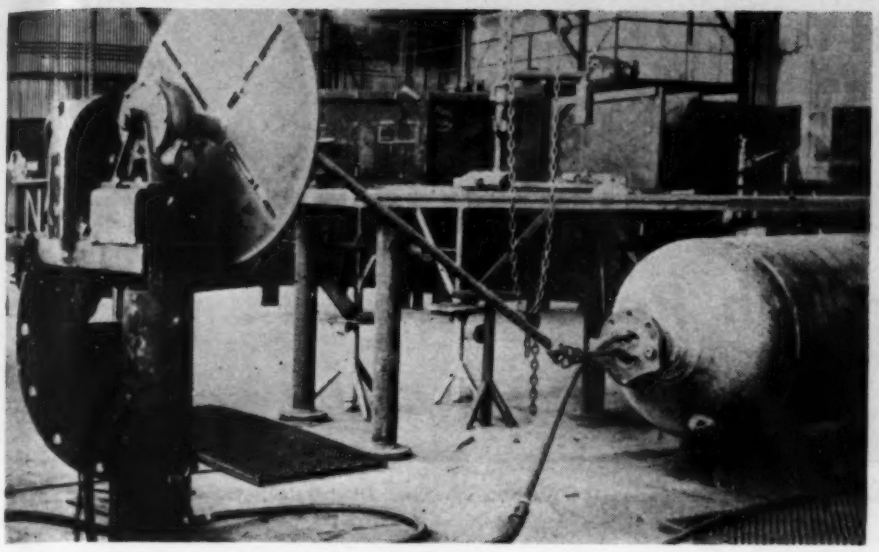
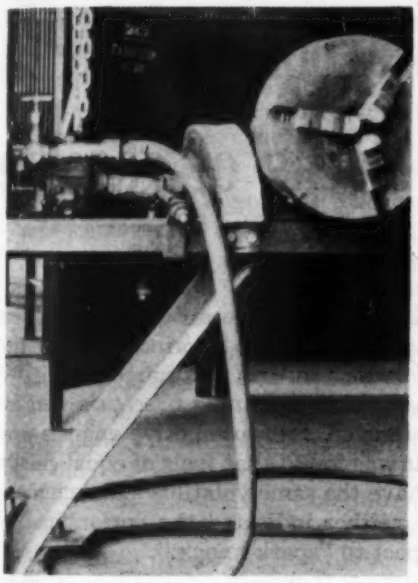




Top photo, above—Shows five adjustment positions in semi-circular plate operating in slot of support. Below—Job rotating unit carrying a late stock head for chucking pump rods or other short pieces of equipment requiring circular welds. Upper right—Job turning machine has been disconnected from drive shaft and used to rotate fire hose connection which is being brazed.

motor connected with a reduction gear box to which several accessories can be attached to facilitate the rotation of a wide range of articles and equipment. A foot-operated throttle valve controls the air supply to the motor, and after a bit of practice the welder can control without any conscious effort the rate of rotation to suit the type and size of electrode, the depth of the weld, and the speed of application best suited to the work at hand.

Figure 1 shows a universal-jointed shaft attachment which permits the rotation of equipment that cannot be conveniently set up at the level of the machine.

Figure 2 pictures a lathe head chuck attachment for rotating small diameter pipe, pump shafts, etc.

Figure 3 shows welder operating the foot throttle and welding a small fitting bolted to the turning head of the machine.

HOW—

Bubble-Caps Can Be Cleaned by Burning

GUM, carbon, and other deposits which form on bubble caps, can be removed effectively by burning the bubble caps under controlled conditions.

One refinery has constructed a small furnace especially for this purpose and this has resulted in efficient reconditioning of the bubble caps with a minimum of labor and time.

The furnace is fired with six burners, three on either side, and installed so that the combustion flame can be directed upon the stacks of bubble caps placed in the fire-box. Air to the burners is regulated and introduced in sufficient quantity to oxidize the deposits on the caps, either causing the carbon etc., to vaporize or flake off.

The sheet metal doors of the furnace are counter-balanced and are opened by a vertical lift. Lift assembly is operated by leverage, utilizing a half-sheave as a fulcrum. Door lever is located on the side of the furnace allowing the operator to open the door without being subjected to intense heat.

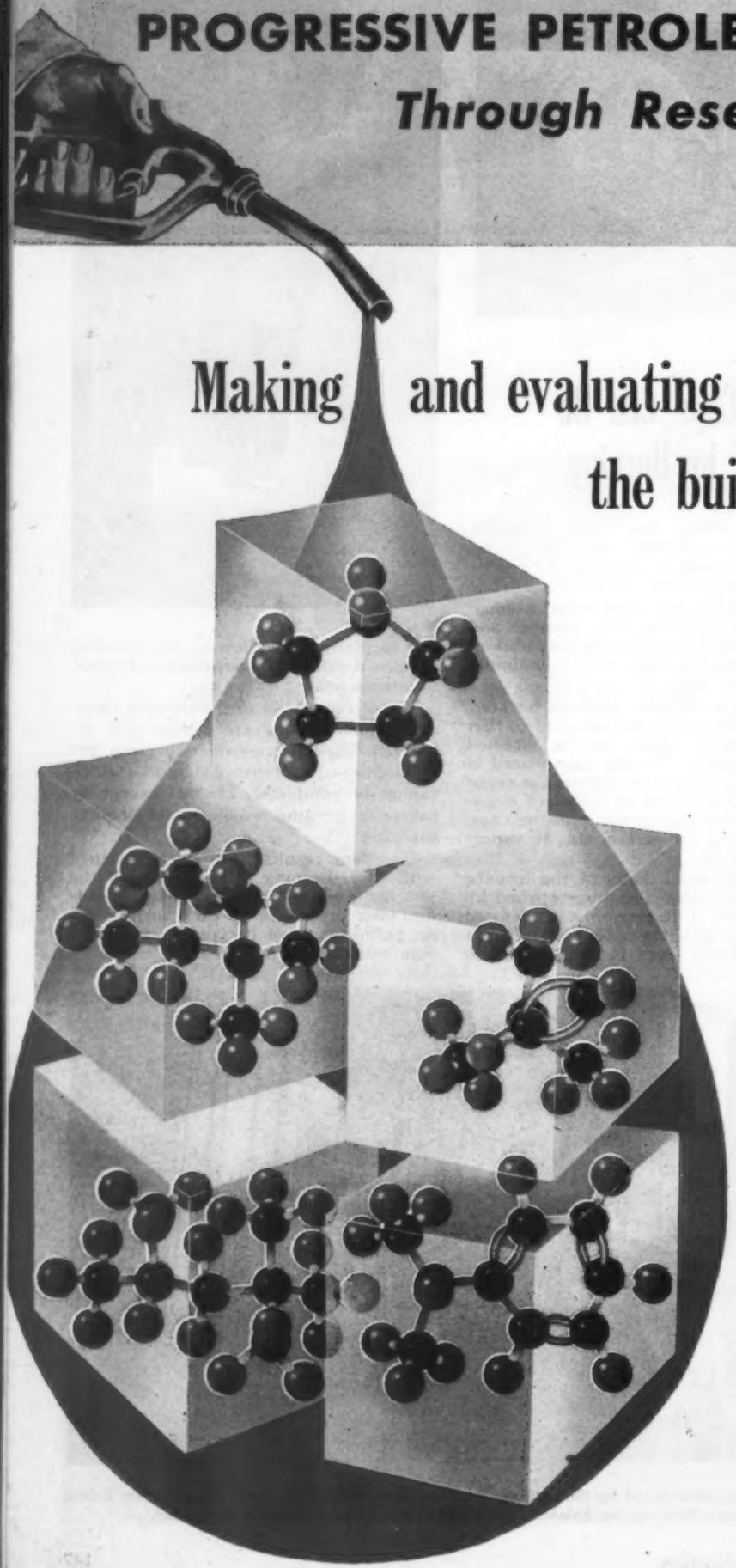
Upon completion of the burning operation, bubble caps are cooled and inspected. Caps not completely clean are hand-chipped to remove deposits which cannot be completely cleaned except by excessive burning which would damage the caps.

Excellent results have been obtained with this burning technique and the process is employed as a standard reconditioning procedure at each turnaround on bubble caps of certain fractionating equipment at this refinery.

Small furnace constructed for the purpose of burning gum, carbon and other deposits from bubble caps. Note counter-balanced doors. Note stack of bubble caps in foreground.

THE ETHYL CORPORATION SERVES THE PROGRESSIVE PETROLEUM INDUSTRY

Through Research

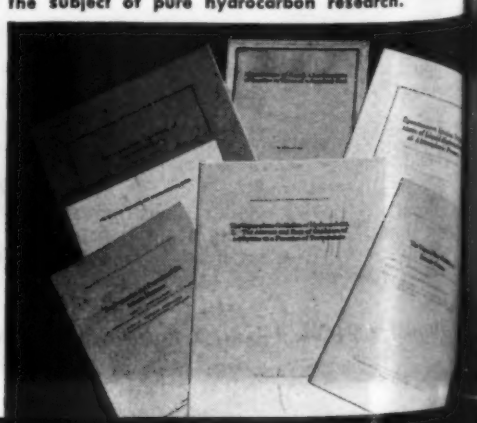


Making and evaluating hydrocarbons— the building blocks of gasoline

IN THE EARLY DAYS of the automobile, gasoline quality was considered to be principally a matter of volatility, which in turn was roughly indicated by "gravity." As new refining processes were introduced, however, and automotive engines were improved, it was found that fuels of equal gravity might not have the same volatility characteristics —and that neither indicated the performance of fuels in respect to "spark knock."

As a consequence, it was reasoned that fractions of given volatility from different crudes might be different in chemical nature and thus cause differences in behavior during burning in engines. Ethyl's research workers were among the first to conclude that a satisfactory explanation of differences in behavior of fuels in engines would require the maximum information concerning fuel hydrocarbons—the building blocks of which all petroleum products are composed.

Thus, nearly twenty-five years ago, was born



Numerous technical papers have been written by the Ethyl Research Laboratories staff on the subject of pure hydrocarbon research.

Ethyl Corporation's Detroit Laboratories are designed for research on problems of fuel-engine-lubricant interrelationships.

the idea behind one of Ethyl's fundamental research programs, which has been carried on continuously ever since for creation of a background of knowledge about hydrocarbons, and particularly about the combustion of hydrocarbons.

In 1926 the Ethyl Laboratories prepared all of the heptanes and a number of octanes. Among these early chemical curiosities was triptane, which is among the best of antiknock fuels known today. Normal heptane and iso-octane were first proposed by Ethyl as antiknock reference fuels, and have since proved of inestimable value for this purpose.

During the intervening years many more pure hydrocarbons have been isolated and studied. The Ethyl Laboratories have, in addition to work done independently, cooperated extensively with other laboratories of the oil and automotive industries in a program for the preparation and testing of as many as possible of the hydrocarbons likely to be present in gasoline. Research conducted or financed by Ethyl has included studies of hydrocarbons in specially designed engines, in laboratory combustion apparatus, and in spectroscopic equipment.

Background information on hydrocarbons is used by Ethyl, in cooperation with oil companies, for studies of experimental and commercial fuels. The aim of these studies is to find the combinations into which such fuels may be blended along with tetraethyllead to form the best and most economical gasoline for present and future engines. As new refining processes are developed, they complicate the technology and economics of gasoline production. Thus these studies become increasingly important both to refiners and to engine manufacturers.

Research on pure hydrocarbons is only one of the services performed by the Ethyl Research Laboratories for the benefit of refiners. Future messages in this series, of which this is the fifth, will discuss other phases of the complex problem faced by refiners in providing gasoline for today's and tomorrow's engines, and the contributions of the Ethyl Corporation to their solution.

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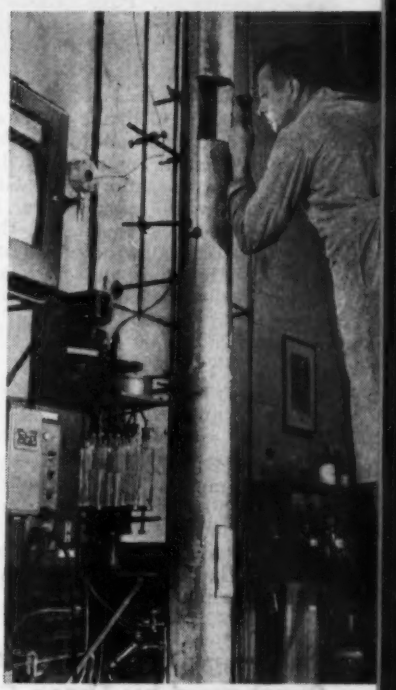
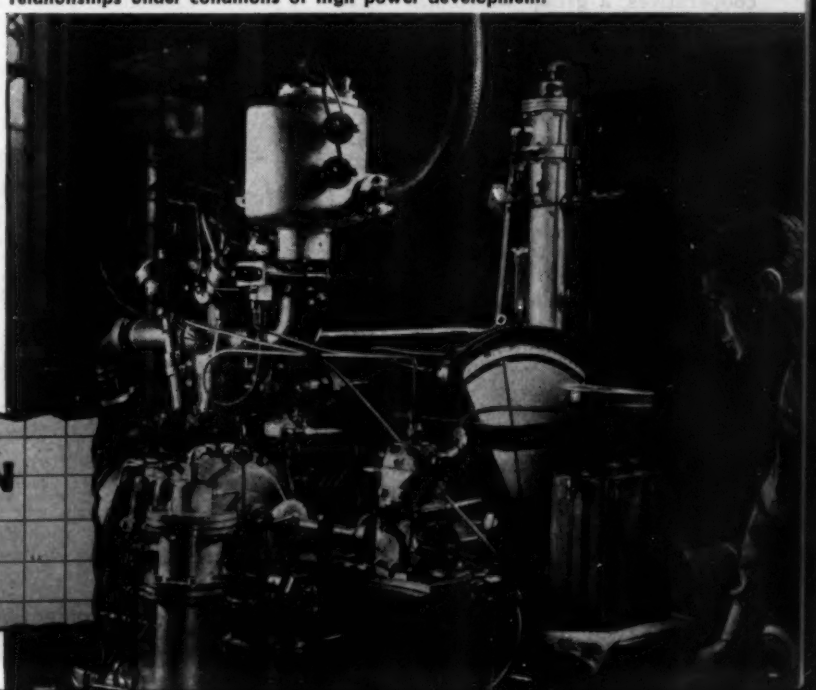


This 16-ft. distillation column is used for the preparation of pure hydrocarbons.

★ ★ ★

This supercharged "17.6" engine is used in research on pure hydrocarbons. The engine was designed and developed in the Ethyl Laboratories especially for research on fuel-engine relationships under conditions of high power development.



ETHYL CORPORATION

RESEARCH LABORATORIES

1600 West Eight Mile Road, Detroit, Michigan

2600 Cajon Road, San Bernardino, California

THE MONTH IN THE INDUSTRY

Phillips Chemical Company Set Up as Separate Entity

Phillips Chemical Company, a new wholly-owned subsidiary, will head chemical activities of Phillips Petroleum Company, the new company being organized to handle Phillips chemical, synthetic rubber, and carbon black operations. Approximately $16 million will be spent directly on the program of the new company in which nearly $100 million has been invested by Phillips Petroleum and the government, K. S. Adams, president, said.

Officers of the new company are Frank Phillips, chairman; K. S. Adams, president; Ross W. Thomas, executive vice president; Paul Endacott, Don Emery, G. G. Oberfell, and R. C. Jopling, vice presidents, and G. W. McCullough, vice president and general manager.

The Cactus Ordance Works at Etter in the Texas Panhandle has been leased by the chemical company as the nucleus of its program and PCC will build a new ammonium plant there. Presently, Cactus Ordance is one of the largest ammonia plants in the world and will be used by the company to produce ammonia for nitrogenous fertilizers. PCC expects to double the plant's present capacity of 70,000 tons.

Under a lease agreement, products from the plant will be purchased by the government until June 30, 1952. At that time the company will divert production to the domestic fertilizer market.

The company plans to build a multimillion dollar plant on the ship channel at Houston, for the production of ammonium sulfate fertilizer. The site is reported large enough for other chemical plants planned by PCC.

Refining Company Interest Purchased by Three Co-Ops

A substantial interest in Premier Oil Refining Company of Texas and Baird Refining Company have been acquired by three large Middle West petroleum cooperatives, a group which has organized Premier Petroleum Company, a Minnesota Corporation, with permit to do business in Texas.

These three co-ops are Illinois Farm Supply Company, Midland Cooperative Wholesale and Farmers Union Central Exchange, Inc., all engaged in distributing petroleum products to the farmers in the Middle West and at present operating other refineries which supply a portion of their total petroleum requirements.

Premier Oil Refining Company will continue to be operated under the same management and will maintain the same general policies, it was announced:

Shell Chemical's Main Offices Go to New York

Shell Chemical Corporation, a subsidiary of Shell Oil Company, engaged in the manufacturing and sale of chemical products since 1929, is planning transfer of its administrative offices from San Francisco to New York in the near future.

The firm's operations on the Pacific Coast will be in no way affected, said officials who pointed out that Shell Chemical will continue to maintain a Pacific Coast headquarters in San Francisco.

Western Refiners Dates

Western Petroleum Refiners Association will hold its 37th annual meeting at the Plaza Hotel in San Antonio March 28-30, 1949.

Meetings

August

30 to Sept. 3—Eastern Session, American Chemical Society, Washington, D. C.

September

6-10—American Chemical Society, Division of Petroleum Chemistry, fall meeting, St. Louis.

9-10—Refractories Division, American Ceramic Society, Fall Meeting, Conneaut Lake Park, Pa., Hotel Conneaut.

13-17—Third Instrument Conference and Exhibit, Philadelphia, Convention Hall.

13-17—Western Session, American Chemical Society, Portland, Ore.

15-17—National Petroleum Assn., meeting, Atlantic City, Hotel Traymore.

16—API Lubrication Committee, Atlantic City, Hotel Traymore.

20-22—National Butane - Propane Association, Chicago.

27-28—Independent Petroleum Association of America, San Antonio, Plaza Hotel.

October

4- 9—American Gas Association Convention, Atlantic City, Ambassador and other hotels.

8—California Natural Gasoline Association, annual fall meeting, Los Angeles, Ambassador Hotel.

11-13—National Lubricating Grease Institute, annual convention, Chicago, Edgewater Beach Hotel.

12-16—National Chemical Exposition, Chicago, Coliseum.

14-15—Indiana Independent Petroleum Association, Indianapolis, Hotel Severin.

14-15—Texas Mid-Continent Oil & Gas Association, Fort Worth.

15-16—American Oil Chemists Society, New York.

23-29—American Society for Metals annual convention, Philadelphia, Benjamin Franklin Hotel.

25-28—Metals Institute Division AIME fall meeting, Philadelphia, Hotel Adelphia.

25-29—American Welding Society annual convention, Philadelphia, Bellevue-Stratford Hotel.

25-29—National Metal Congress and Exposition (American Society for Metals), Philadelphia.

November

4- 5—Society of Automotive Engineers, Fuels-Lubricants Division, Tulsa, Mayo Hotel.

8- 9—API Lubrication Committee, Chicago, Stevens Hotel.

8-11—American Petroleum Institute, annual meeting, Chicago, Stevens Hotel.

28—to Dec. 3—American Society of Mechanical Engineers annual meet, New York.

29—to Dec. 4—18th National Exposition of Power and Mechanical Engineering, New York, Grand Central Palace.

Mekler Joins Stanford Research as Consultant

Lev. A. Mekler, petroleum engineer and technologist, has been named a consultant for the Stanford Research Institute, Stanford University, Calif.

Mekler has his own engineering consulting firm and will serve in a part-time advisory capacity for the institute and its commercial sponsors while retaining his office in Chicago.

Born in Russia in 1894, Mekler was educated in Manchuria, the University of Glasgow and the University of California where he received his Bachlor of Science degree in 1919.

Except for the period from 1942-43, while he was on loan to the U. S. government in the Petroleum Administration for lend lease to Russia, Mekler has spent most of the last 25 years as combustion engineer, metallurgist and development engineer for Universal Oil Products. In 1945 he joined the staff of Armour Research Foundation and the Institute of Gas Technology, and in 1946 opened his own consulting offices in Chicago, remaining on a part-time basis with Armour.

Mekler has written many articles for scientific journals and is the holder of American and foreign patents.

Petroleum and Natural Gas Now Leading Fuels

Petroleum and natural gas have gained the leadership in the field of energy with the former leader, coal, holding only third position, Washington revealed last month. Consumption of petroleum is 60 percent higher than the 1935-39 period and natural gas has increased 80 percent. Bituminous coal shows a 25 percent gain but anthracite coal has decreased 15 percent. The Commerce Department believes the primary reason for this change in standing is the prewar growth of petroleum-using equipment and the use of natural gas for residential and commercial heating.

Use of diesel-electric locomotives by railroads has increased 10 percent, lowering the consumption of coal by steam locomotives to two-thirds the amount in 1939. Now there are 90 percent more tractors on farms and residential oil burners have increased two-thirds in number since 1939. Iron and steel industries now use 28 out of every 1000 barrels of oil taken from the ground. Residential consumption of natural gas has doubled and commercial consumption has increased 150 percent since 1939. Gas prices are about the same but bituminous coal has risen 83 percent, anthracite 64 percent and petroleum 133 percent.

Esso Standard Changes

Harold Sydnor, formerly coordinator of fuel products operations, has been named assistant to the vice president in charge of manufacturing, by Esso Standard Oil Company.

Thomas W. Moore was named coordinator of refining operations and assistant to the general manager. Also named an

Reducing Dezincification

Admiralty, Muntz Metal and Aluminum Brass condenser and heat exchanger tubing is used extensively in petroleum refineries, petro-chemical and chemical plants. Admiralty still is the most popular all-around heat exchanger and condenser tubing alloy used in oil refineries. Because of high zinc content, dezincification on the water side was for many years a frequent cause of premature failure of such tubing. During the past decade dezincification has been considerably reduced by the more widespread use of the same alloys containing dezincification inhibitors. However, some operators are having trouble with dezincification where uninhibited Admiralty is still in use.

How Dezincification Is Recognized—Dezincification is a type of corrosion occurring in uninhibited brass alloys containing a high percentage of zinc. It is recognized by the presence of reddish-brown areas which may be in the form of plugs or continuous layers. Analyses of these brittle deposits prove them to be approximately 100% copper. This is known as dezincification because the zinc has gone into solution in the circulating water, leaving redeposited copper.

In some cases, other forms of corrosion may be mistaken for dezincification. When in doubt, it is suggested that operators submit full length samples of tubing to Bridgeport's laboratory for examination. Samples should be carefully marked as to inlet end, top and bottom, and location in the unit, and accompanied by pertinent data regarding operating conditions, water analyses, etc.

Factors Favoring Dezincification: Dezincification occurs in many different types of waters—both salt and fresh. It is favored by:

(a) a limited supply of dissolved oxygen as found beneath semi-porous deposits such as rust, cotton, lint, decomposing wood, silt, etc.;

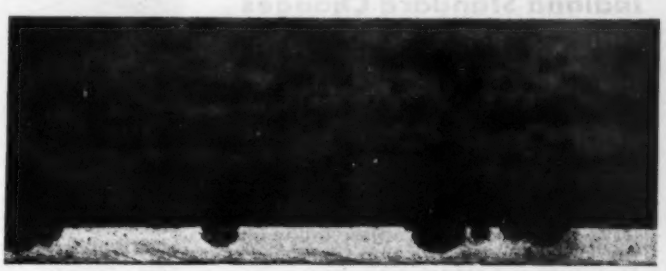
(b) the presence of certain salts, particularly the chlorides and to a lesser extent sulfates and nitrates—for example, the rate of dezincification in sea water is considerably more rapid than that encountered in fresh water;

(c) soft, non-scale-forming fresh water;

(d) low water velocity which permits deposition of foreign matter;

(e) elevated temperature which generally accelerates dezincification.

Preventing Dezincification—Investigation has shown that dezincification can be stopped or inhibited by adding inhibitors—arsenic, tin, antimony or other elements. Arsenic has proved very dependable and since 1936 the addition of arsenic to condenser tube alloys has been standard practice with Bridgeport Brass Company.



Illustrating typical plug-type dezincification in uninhibited brass condenser tubing. Longitudinal section mag. about 4X.

The addition of arsenic, even in concentrations as low as 0.01%, is very effective in reducing dezincification of Admiralty or Aluminum Brass. A somewhat higher concentration of arsenic is used in Muntz Metal*, and has proved quite effective. Addition of arsenic to Muntz Metal also has lowered the over-all corrosion rate about two-thirds under certain conditions. Arsenic also improves the over-all corrosion resistance of Duronze IV** (aluminum bronze).

Preventive Measures—In view of the fine results obtained from Arsenical Admiralty, Arsenical Aluminum Brass, Arsenical Muntz, etc., one of the surest methods of combating dezincification is to use such inhibited alloys. Other measures consist of maintaining as low temperatures as practical and keeping tube surfaces smooth and clean.

Contact the nearest Bridgeport office for information about available condenser tube alloys, and write for 120-page Condenser Tube Manual containing valuable information on condenser tubing, corrosion research, etc.

*Reg. U. S. Pat. No. 2118688
**U. S. Pat. No. 2093380

"Bridgeport" BRASS CO.

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONN. • *Established 1865*
Mills at Bridgeport, Connecticut, and Indianapolis, Indiana
In Canada—Noranda Copper and Brass Limited, Montreal

CONDENSER AND HEAT EXCHANGER TUBING

assistant to the general manager was Herbert R. Poland who will be in charge of long range planning and special manufacturing studies. Claude J. Bigelow was appointed coordinator of East Coast refining operations and secretary of the East Coast manufacturing committee succeeding Moore.

Sydnor has been a member of Esso Standard for 28 years.

Indiana Standard Changes

Three changes in personnel were announced in July by Standard Oil Company (Indiana).

Dr. O. E. Bransky, assistant general manager of the manufacturing department, will retire September 1 after 38 years with the company.

Dr. W. J. McGill was promoted to superintendent, manufacturing operations in the Chicago office, following a reorganization. He is a graduate of the University of Michigan.

J. C. Ducommun will succeed Dr. McGill as manager of the Whiting, Ind., refinery. A graduate of the University of Iowa, he has been with the company since 1929.

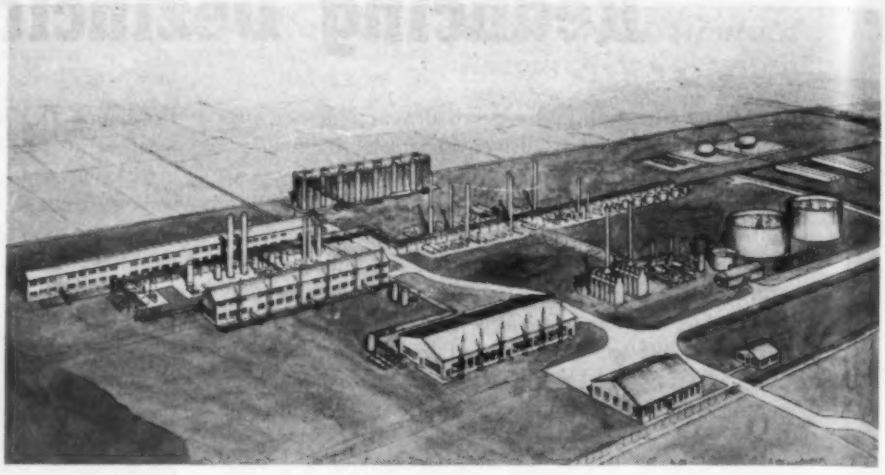
Franklin Institute Potts Medal to Eugene Houdry

Eugene J. Houdry of Mill Creek Road, Ardmore, Pa., will receive a 1948 Potts Medal from The Franklin Institute "in consideration of his leadership in the development of catalytic cracking of petroleum that bears his name, utilizing known basic chemical and physical facts." The medal will be presented to Houdry by Richard T. Nalle, president of The Franklin Institute, at traditional Medal Day ceremonies in Philadelphia next October 20.

E. J. Houdry

For several years after World War I, Houdry led efforts in France to manufacture gasoline from lignite and coal by a process involving catalysis but these attempts proved unsuccessful commercially. In 1926 he began his own experiments in catalytic cracking of petroleum and developed a process which proved successful in laboratory trials. He entered the U. S. in 1930 to continue development of his process for Vacuum Oil Company in Paulsboro, N. J. Vacuum merged with Standard Oil Company of New York, becoming the Socony-Vacuum Oil Company, before the Houdry process was developed on a commercial scale. Meanwhile, Houdry interested Sun Oil Company in his process. Thus the process was brought to large scale commercial use under the sponsorship of the two oil companies and Houdry's French supporters. During the early part of World War II Houdry catalytic cracking units supplied a bulk of all the aviation gasoline base stock made in this country.

Gasoline Plant Near Levelland, Texas



Above is an architect's sketch of the new Slaughter natural gasoline plant being built by Stanolind Oil and Gas Company in Hockley County, Texas, 13 miles southwest of Levelland. The plant will be operated by Stanolind and owned jointly by eight firms, including The Texas Company, Honolulu Oil Corporation, Magnolia Petroleum Company, Devonian Oil Company, The Atlantic Refining Company, Mid-Continent Petroleum Corporation, Saltmount Oil Company, and Stanolind. The plant will process about 90 million cubic feet of gas daily to produce about 250,000 gallons of liquid products, of which 100,000 gallons will be natural gasoline. The remainder will be butane and propane. Residue gas will be sold. Operations are expected to begin in February, 1949.

Demand and Production of LPG Said About Equal

Annual demand for liquefied petroleum gas is about to equal annual production, NPC's committee on LPG advised late in July. Makers and distributors were asked to build up their storage facilities to be able to handle a maximum volume and to establish tankage at advantageous points.

Estimated annual production rate of LPG for the next two years is 3,263,881,600 gallons for 1948 and 3,771,886,000 for 1949. With present estimated demand for 1948 at 3,194,102,000 and for 1949 at 3,755,220,000, production likely would get ahead of demand, but seasonal periods of peak consumption may make the amount not sufficient for the demand, it was said.

Chemical Would Prevent Rust in Tanks and Lines

Rust prevention in pipe lines, large storage tanks, tank cars, automobile tanks, and consumers' heating oil tanks is now accomplished by an additive known as RD-119, developed by the research department of Sinclair Refining Company. Injection of RD-119 is done at the manufacturing point, and from that time on it acts to form a protective coating on metal surfaces with which the product containing it comes in contact, it is claimed. It gives an "invisible, polymolecular protective layer, which prevents the metal surfaces from coming in contact with any air or moisture in the product." This protection includes prevention of rusting of steel surfaces and corrosion of copper, aluminum, brass, and other surfaces.

Petroleum products such as gasolines, kerosines, and heating oils, in the course of their handling pick up an infinitesimal amount of air and moisture and where the products are handled in large quantities over long periods, the cumulative effects of this small amount of air and water (both of which induce rusting and corrosion of metal surfaces) is apparent. Product pipe lines also need protection against rusting.

The additive does not affect the specification tests or performance of the products to which it is added, and will not result in any higher cost to the ultimate consumers of products so treated.

Patent applications covering this development have been filed, and license agreements which will make it available for use by others than Sinclair Refining Company will soon be obtainable.

Stanolind Changes Listed

Recent promotions and transfers in Stanolind Oil & Gas Company include:

C. P. Allen, from operating engineer, manufacturing department, Tulsa general office, to operating engineering supervisor.

Stanley G. Baker, field clerk at Iles Dome, Loyd, Colo., to plant clerk, manufacturing department, Stanosyn plant, Garden City, Kan.

A. J. Inderrieden, Jr., junior petroleum engineer, producing department, Tulsa general office, to depreciation engineering supervisor, economics department.

Herbert B. Langford, Jr., from mechanical engineer, manufacturing department, Slaughter plant, Levelland, Texas, to senior mechanical engineer.

A. M. Rentz and D. B. Warner, engineers at Salt Creek, Wyo., gasoline plant, have been transferred to the manufacturing department of the company's general office at Tulsa.

New Officers of ASTM

Richard L. Templin, Aluminum Company of America, New Kensington, Pa., has been elected president of American Society for Testing Materials succeeding T. A. Boyd, General Motors Corporation, Detroit, Mich., who continues on the board of directors for three

THE MONTH . . .

years. L. J. Markwardt, U. S. Forest Products Laboratory, Madison, Wis., is the new vice president to serve with the senior vice president J. G. Morrow, Steel Company of Canada, Ltd., Hamilton, Ontario, Can.

New directors are as follow:

Leslie C. Beard, Jr., Socony-Vacuum Oil Company, Inc., New York; Simon Collier, Johns-Mansville Corporation, New York; Theodore P. Dresser, Jr., Abbot A. Hanks, Inc., San Francisco; Howard K. Nason, Monsanto Chemical Company, Dayton, Ohio; and Edgar W. Fasig, Lowe Brothers Company, Dayton, Ohio.

Beall Succeeds Sands as Phillips Economics Head

The board of directors of Phillips Petroleum Company last month announced the election of K. E. Beall to the office of vice president, Economics Department, effective July 1. Beall succeeds J. M. Sands who reached retirement age this year.

Beall

Beall joined Phillips in 1920 as a production engineer. Upon the organization of the Economics Department he transferred to that department and since 1946 he has served as manager.

Beall was born at Walton, Ind., and is a graduate of Purdue University.

Phillips Promotes Three, Tate Assistant Manager

Phillips Petroleum Company announced promotions last month as follow:

C. C. Tate to assistant manager of the refining department in charge of supervision of the refineries of Phillips Oil Company, Alamo Refining Company, Wasatch Oil Company, Inland Empire Refineries and Home Oil and Refining Company. He will continue in charge of the Petroleos Mexicanos project. Tate was associated with Texas Pacific Coal and Oil and General Electric before coming to Phillips in 1932.

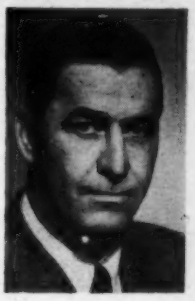
J. W. Loy to general superintendent of the northwest division of the refining department. Loy joined Phillips after graduation from Kansas State University in 1939.

G. E. McKenna to superintendent of Phillips' Borger refinery, succeeding the late R. D. Evans. Previously he was employed by Humble Oil Company, Penna Petroleum Company and Great Lakes Pipe Line Company.

Phillips Venezuelan Oil Company, a wholly owned Phillips Petroleum subsidiary, has changed its name to Phillips Oil Company and acquired assets from Phillips Petroleum consisting of refineries at Kansas City, Kas., Okmulgee, Okla. and Borger, Texas; and all the capital stock of Alamo Refining Company which owns and operates the Sweeny, Texas refinery.

Caltex Names Anderson Middle Eastern Manager

W. P. Anderson has been named general manager of refineries for Caltex, in the East of Suez and Eastern Mediterranean territories.



Anderson

After taking a B.S. degree in chemical engineering from the University of California, Anderson, in 1925, started in the research and development department of Standard Oil Company of California at Richmond. He also served as as foreman of the cracking unit department before going to Bahrein Island in 1936 as superintendent of the Caltex refinery then being built.

Anderson became general manager at Bahrein in 1942 and continued until 1946 when he was transferred to the New York offices of Caltex.

Crude "Finding List"

A master list or "finding list" of publications containing detailed analyses of both domestic and foreign crude oils analyzed by the standardized Bureau of Mines method has been issued by the bureau. References to crude oil analyses from 22 states and Alaska as well as 34 foreign countries in both hemispheres are included and changes in the names of fields since the original publication of analyses also are indicated.

A free copy of the index, titled Information Circular, 7470, "Bibliography of Reports Containing Analyses of Crude Oil by the Bureau of Mines Method," may be obtained by writing to the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13.

Foreign Trade Posts

New foreign trade appointments made last month by Socony-Vacuum Oil Company include:

R. S. Homet as general manager of the foreign trade department; F. E. Powell, Jr., continues as chairman of the foreign trade committee; J. J. Pettey becomes a member of the foreign trade committee with responsibilities in the Mediterranean area; Philip Clover becomes a member of the foreign trade committee with responsibility for South and Central America, Germany and Austria and J. S. Vesey Brown manager of the West Africa division.

Kirk Heads CNGA

W. A. Kirk, California Southern Oil Company, took over the leadership of the California Natural Gasoline Association at the annual meeting of the board of directors July 14. He succeeds Frank J. Colton, Tidewater Association Oil Company.

Other officers elected were J. B. Taylor, Signal Oil & Gas Company, vice president; Paul Armstrong, sales engineer; F. E. Bradley, C.C.M.O.; R. O. Boykin, Fullerton Oil Company; L. P. Foote, The Ohio Oil Company; P. E. Foote, Petrolane, Ltd.; R. E. Foss, Barnsdall Oil Company; N. A. Rousselot, Seaboard Oil Company; and Leland K. Whittier, Belridge Oil Company, directors. E. R. Millett, Jr., was reappointed secretary-treasurer.

NPC War Organization Group Headed by Jennings

B. Brewster Jennings, of Socony-Vacuum Company, is chairman of the National Petroleum Council committee, appointed to study and recommend "the nature of government, government-industry and industry organization procedures and policies that would best meet the needs of a future war emergency." J. R. Parten, Houston, Woodley Petroleum Company is vice chairman.

The committee also includes: Bruce K. Brown, Indiana Standard Company; H. S. M. Burns, Shell Oil Company; J. C. Donnell II, Ohio Oil Company; B. I. Graves, Tide Water Associated Oil Company; D. A. Hulcy, Lone Star Gas Company; J. A. Lentz, Contintental Oil Company; B. L. Majewski, Deep Rock Oil Corporation; J. Howard Marshall, Ashland Oil & Refining Company; Glenn Nielson, Husky Refining Company; John Newton, Magnolia Petroleum Company; S. F. Niness, National Tank Truck Carriers; H. J. Porter, Independent Producers and Royalty Owners Association; Claude Parsons, Spartan Tool Company; E. E. Pyles, Jergins Oil Company; W. R. Reitz, Quaker State Oil Refining Corporation; W. S. S. Rodgers, The Texas Company; Stribling Snodgrass, Bechtel Corporation; Reese Taylor, Union Oil Company; and W. W. Vandeveer, Allied Oil Company.

Conoco Lists Promotions

Six promotions among key personnel of Continental Oil Company's manufacturing department were announced last month as follow:

J. H. Olehy, with the company since 1927, appointed supervisor of technical services, succeeding L. L. Davis, recently named manager of the company-wide development and research department.

J. H. Smith named chief process engineer succeeding Olehy. Smith is a graduate of Purdue University.

B. H. Lincoln named patent adviser of the development and research department, was employed by the state of Colorado before joining Continental in 1926.

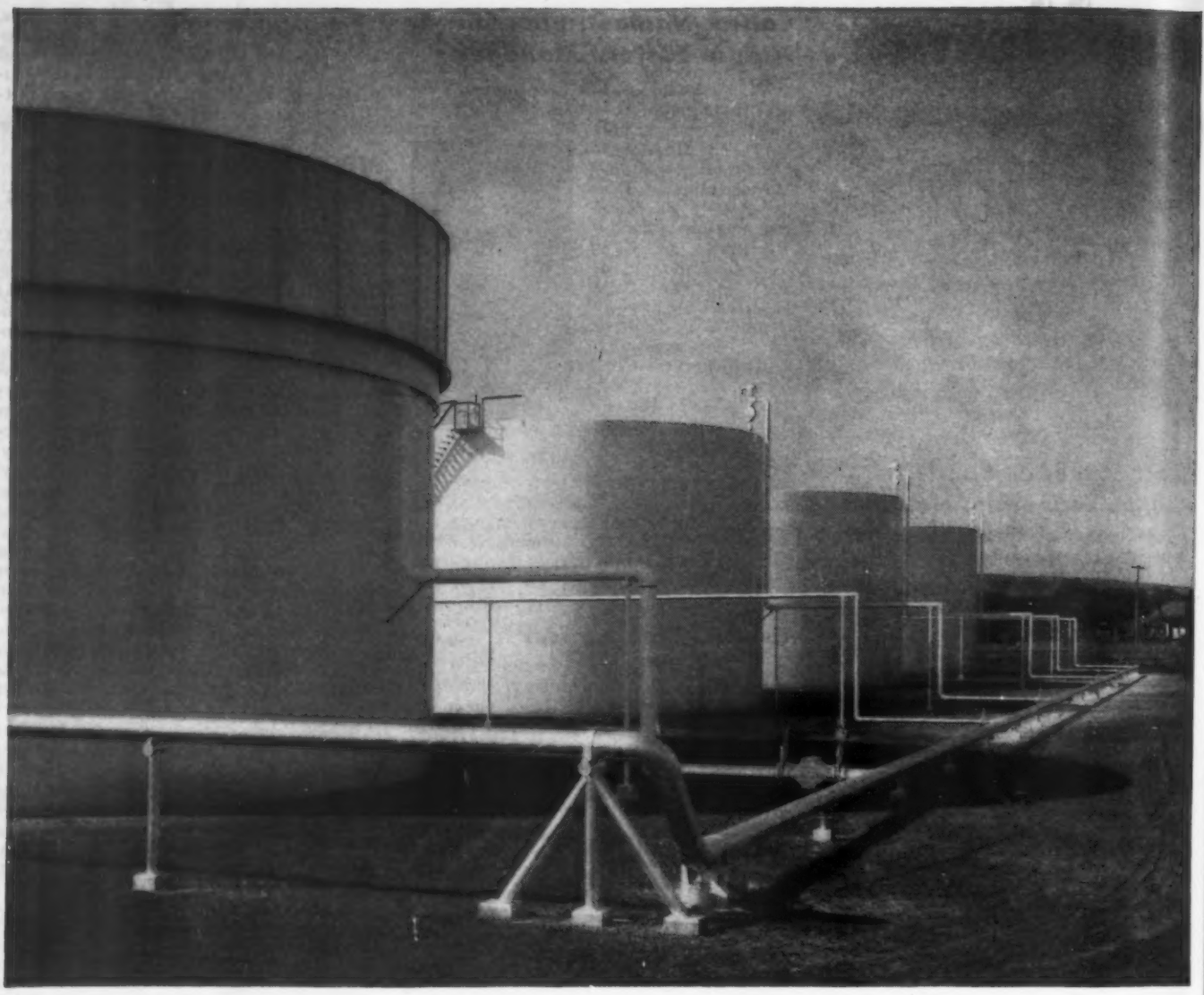
C. A. Nielson was appointed chief chemist, succeeding Lincoln and Horace E. Luntz was promoted to superintendent of the process laboratory succeeding Nielson.

A. M. Hovlid named to the newly created position of personnel supervisor, manufacturing department, will hold this position in addition to his present duties as assistant to manager, manufacturing department.

New API Directors

Four changes on its board of directors were announced last month by the American Petroleum Institute as follow:

L. F. McCollum, president, Continental Oil Company, Ponca City, Okla., vice the late D. J. Moran of the same company. McCollum also was elected



PARTY LINE—REFINERY STYLE

It's the manifold line connecting standard cone roof tanks to a Graver Expansion Roof tank. Progressive refiners (and terminal operators) have found this "party line" the perfect solution to their vapor loss problems.

A closed system is formed with a single Expansion Roof tank and as many as eight cone roof tanks using the manifold line. As vapors expand due to rises in temperature or as they are displaced during filling operations, they travel through the manifold line into the vapor space of the Expansion Roof. The roof rises to accommodate these vapors and venting to the atmosphere is prevented.

When temperatures drop or pumping out takes place, the vapors travel back to the vapor spaces of the various tanks and the roof descends. There is no breathing in of moisture laden air.

For details on applying the "party line" system to your petroleum storage facilities, write today.

FABRICATED PLATE DIVISION

GRAVER TANK & MFG. CO., INC.

East Chicago, Indiana

Graver offers a complete service to the petroleum industry including Expansion Roof Tanks, Floating Roof Tanks and pressure vessels. In addition, Graver is prepared to furnish specialized steel plate work such as fractionating columns and class one vessels as well as stainless and alloy fabrication; water conditioning equipment of all types; and through its General Construction Division is prepared to handle all types of installation and erection work.

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NEW YORK • PHILADELPHIA • CHICAGO • CATASAUQUA, PA. • HOUSTON • SAND SPRINGS, OKLA

THE MONTH...

to membership of the Institute's Executive Committee in place of W. S. Ferguson, Continental Oil, Denver, resigned.

J. H. Peper, Northern Pipeline Company, New York, vice D. S. Bushnell, of the same company, resigned.

A. W. Ambrose, Cities Service Oil Company, Bartlesville, Okla., vice H. R. Straight, Bartlesville, resigned.

Burl S. Watson, Petroleum Advisers, Inc., New York, vice Harry D. Frueauff, of the same organization, resigned.

New Pipe Line To Supply Several Big Refineries

A 650-mile, 20-inch crude oil pipe line, the longest built since the war, was officially opened at Patoka, Ill., early last month. The line, built by Magnolia Pipe Line Company extends from Corsicana, Texas, to Patoka and will supply crude oil through connecting lines to refineries in East Chicago, East St. Louis, Trenton, Mich., Buffalo and other cities.

The new line will pump 100,000 barrels of oil a day.

Steel Mill Starts

The first shipment of pipe from Republic Steel Corporation's new large-diameter pipe mill left the Gadsden, Ala., plant July 1. The shipment is the first of a total of 140 miles of 24-inch pipe line pipe which Republic will make on the new mill for Southern Natural Gas Company, Birmingham.

The first shipment amounted to about two miles of pipe. When operating at full capacity—expected by January 1, the mill will produce about 65 miles per month.

Sinclair Closes Plant

With the completion of its oil products pipe line between Houston and Fort Worth, Sinclair Refining Company has closed its small refinery at Fort Worth and the refinery will be dismantled.

In view of this development, it is thought likely that Sinclair plants at Kansas City, Kan.; Coffeyville, Kan.; and Sand Springs, Okla. will be closed when the products pipeline from Houston to East Chicago, Ind. is completed. Although no official announcement was available on the matter.

Torrance Safety Wins

The Torrance, Calif. refinery of General Petroleum Corporation received an API "One-Million Hour Certificate" for establishing a safety record of 1,180,000 man hours of work without a disabling injury. During the 211-day period each unit was shut down and overhauled as part of an electrical conversion program from 50 to 60-cycle power.

Operating personnel and crafts in the refinery are represented on the foreman and workmen safety committees, which devise safety practices, recommend policies and disseminate safety information to their fellow workers.

Ford

Reynolds

Barnes Company Announces Two New Vice Presidents

Two vice presidents have been named by W. M. Barnes Company, Los Angeles, as follows:

John E. Ford, Jr., in charge of engineering and sales, formerly was manager of commercial development for Houdry Process Corporation. He participated in the planning and construction of the first small-scale catalytic cracking plants and later was project engineer on the synthetic rubber plant at Sarnia, Ontario, Canada. Ford also was associated with The M. W. Kellogg Company.

J. S. Reynolds, in charge of construction, began his career as an engineer with Esso Standard Oil Company and later joined Kellogg. Wilmington Construction Company was organized by Reynolds and is now owned by the Barnes Company. Reynolds dismantled the refinery at Whitehorse, Alaska, and re-erected it at Edmonton, Alberta, Canada, for Imperial Oil Company, Ltd.

Reichl Named Manager

The research and development division of Pittsburgh Consolidation Coal Company has promoted E. H. Reichl to the position of manager of its research department. During the past three years engaged in exhaustive investigations abroad of Germany's synthetic oil research and operations, Reichl came with Pittsburgh Consolidation in January, 1948, as chief process engineer of the development department.

Ethel Hurst Honored

Miss Ethel W. Hurst was honored last month by Petrol Terminal Corporation of Philadelphia on her 10th anniversary as vice president, assistant treasurer and director of the company. One of the founders of the fuel oil distributors company, Miss Hurst was presented with a silver set. E. M. Callis, president, made the presentation.

Hurst

Officers and directors besides Miss Hurst and Callis, re-elected at a meeting before the presentation were F. F. Sweeton, vice president and director in charge of transportation and crude oil purchasing; V. E. Smith, vice president in charge of manufacturing at Texas City; C. W. Whitney, vice president and director in charge of sales; and J. A. Spahn, secretary.

Military Training Leaves Allowed by Oil Companies

Formal policies on employes' leaves of absence for temporary duty in military reserve organizations for training purposes have been adopted by most of the large integrated oil companies. Now that the official status of the new draft law is known, some of the remaining companies are expected to formalize policies within the next 60 to 90 days and others will revise existing policies to conform with industry practice.

Policies generally provide for two weeks or 15 days of absence and do not affect regular vacations to which employees may be eligible. Nearly all the companies make up the difference between employes' military pay and regular company pay.

U. S. Military Demands Its Full Oil Requirements

The military will resort to mandatory powers granted by the draft act of its petroleum requirements are not met "within one week," National Petroleum Council was advised late in July.

Although there has been a great spirit of co-operation and many companies have gone all-out to meet requirements, nevertheless, in certain important categories, requirements have not been met, Washington claimed. As a result the military says it has not been able to build up to what are considered bare essential working stock levels. Being as requirements are at the absolute minimum, even a slight deficiency is something that must be corrected, it said.

Refining Bottleneck Seen If Demand Keeps Increasing

Refining capacity may develop a serious bottleneck in the next 12 months if demand continues to increase, NPC was told last month. Domestic capacity by the end of 1948 would be 5,919,000 barrels daily greater than the estimated 5,845,000 for last June 30.

Robert E. Wilson, Standard Oil Company (Indiana), chairman of NPC's committee on petroleum refining capacity, last month explained that "it is quite apparent that the expansion of refinery throughput, which has recently set new high records almost every month, must flatten off from now on. The industry is today operating even its relatively inefficient refining units substantially at capacity. At the same time it is making almost superhuman efforts to expand refinery capacity, even in the face of high construction costs and steel shortages."

A survey of refinery capacity, which will cover projected expansion by quarters through 1949, will be prepared by Wilson's committee in September, subject to NPC approval.

Upped Production Needed In Kerosine, Heating Oils

Output of heating oil and kerosine for East Coast use must be stepped up by refiners, following a delay in Justice Department's approval for voluntary oil allocations agreement.

"Petroleum is still a scarce commod-

THE MONTH...

ity" Walter S. Hallanan, NPC chairman explained, "and any rapid expansion in demand can result in temporary shortages of supply, the degree of which will be in relation to the severity and nature of the cause. However, the general heating oil outlook has improved considerably."

The industry has anticipated oil needs with a $5 billion expansion program, he pointed out. Due to new highs in well completions, crude production, crude runs to refineries and output of products, new seasonal marks exist in products stock levels. More tankers will be available and oil pipe line facilities also have been expanded. Kerosine stocks on the east coast are up 16 percent, he said, but current kerosine yields are 5 percent down from last year's level. On the other hand refinery yields of distillate are up 2 percent from last year.

Houdry Names Kirkbride In Charge of Research

C. G. Kirkbride last month was elected vice president in charge of research and development of Houdry Process Corporation, Philadelphia.

Author of the textbook, "Chemical Engineering Fundamentals," Dr. Kirkbride is a former professor of chemical engineering at Texas A. & M. College. He is director of the American Institute of Chemical Engineers and secretary-treasurer of the petroleum chemistry division of the American Chemical Society.

Kirkbride

Before joining Houdry, Dr. Kirkbride served as chief of chemical engineering development for Magnolia Petroleum Company at its Dallas laboratories; assistant director of research for Pan American Refining Company; and chemical engineer in the Whiting Laboratories of Standard Oil Company (Indiana).

Rust Company to Build Socony-Vacuum's Units

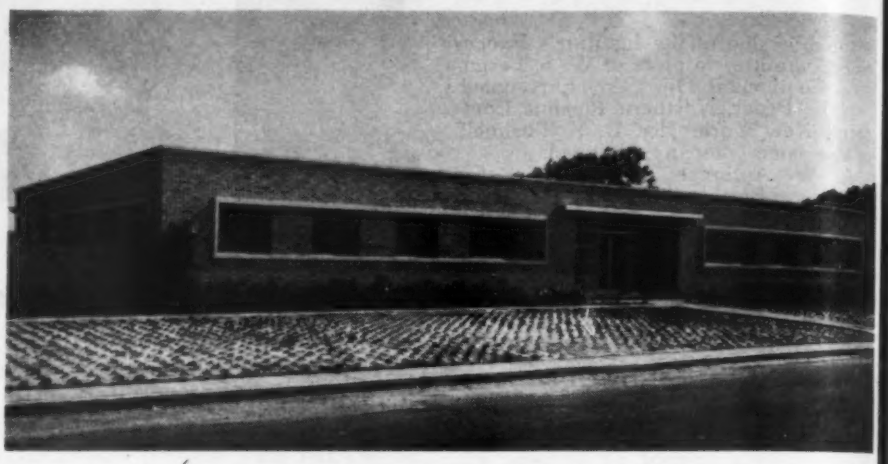
The Rust Engineering Company of Pittsburgh, has been authorized by Socony-Vacuum Oil Company, Inc., to act as engineer-constructor for units to produce ethylene and aromatics by Socony's Thermofor Pyrolytic cracking process.

An adaptation of the widely used TCC catalytic cracking technique, Socony's new TPC process employs a moving bed of non-catalytic refractory particles as a heat transfer medium in direct contact with the oil to be cracked. Elimination of the coking difficulties encountered in conventional tube cracking permits operating the TPC process with low grade liquid petroleum oils.

While developed primarily for ethylene manufacture, the TPC process is suitable also for the production of aromatic compounds. By proper selection of operating conditions, substantial quantities of aromatics can be produced simultaneously with high yields of ethylene.

It is the combination of low priced charge stocks and valuable by-products that is expected to result in low cost ethylene by the TPC process, Rust engineers point out.

Delta Engineering in New Home



Delta Engineering Corporation recently moved into its new office building at 2121 San Felipe Road, Houston. The new building is functionally designed to meet the company's specific requirements, has an area of approximately 6000 square feet and is air conditioned. Delta Engineering is engaged in the design and construction of natural gasoline recovery, pressure maintenance and gas dehydration plants. Officers are Robert B. Baldwin, president; George L. Gudenrath and Allen R. Salley, vice presidents; and W. J. Geiselman, secretary-treasurer.

Expansion Plans Listed By Refinery Maintenance

The gasoline recovery plant being built by Refinery Maintenance Corporation, Compton, Calif., at Newhall, Calif., for Barnsdall Oil Company is near completion. The plant, designed with a new rich-oil stabilization system, has a capacity of 40 million cubic feet daily.

Organized in 1943 for maintenance work in California plants, Refinery Maintenance has expanded recently under the direction of F. J. Buckner, president, to include straight labor contracts in construction of oil refineries, natural gasoline plants, and other types of industrial construction. Also, the company has been awarded contracts for plant construction in the Mid-Continent and Gulf Coast areas. An office has been opened in Houston to serve these areas.

Contracts have been awarded and preliminary work begun on a gasoline plant near Bloomfield, N. M., for Southern Union Gas Company, a gasoline plant in Crockett County, Texas, for Continental Oil Company and Associates, a cycling plant at Three Rivers, Texas, for Western Natural Gas Company, and a dehydration plant for McCarthy Chemical Company at Winnie, Texas.

Wear Joins Conoco

George Wear, a practicing attorney of Columbia, La., has joined the legal staff of Continental Oil Company at Houston. Wear is a 1940 graduate of Louisiana State University. He served as a pilot and a base legal officer during the war.

L. L. Davis Is Selected as Continental Research Head

L. L. Davis has been appointed manager of the newly created development and research department of Continental Oil Company. He will coordinate development and research activities in all its phases from all departments of the company.

Davis

A pioneer in the development of synthetic additives for use in lubricating oils and in research and development of lubricating greases, Davis has been with Continental for more than 21 years. Starting out as technician and assistant superintendent of the Ponca City refinery in 1927, he was assistant general superintendent and acting general superintendent by 1928. Davis was promoted to supervisor of the process division in 1929 and has since been supervisor of technical services of the entire manufacturing department. At present he is chairman of the research committee and a member of the advertising committee and the manufacturing and sales committee.

Sunray Figures Gain

Sunray Oil Corporation last month reported it is now processing 58 percent of its own daily oil production, against a throughput of 29 percent of production reported for the first six months of 1947. July and August processing figures are expected to show an even higher jump, officials declared.

Meter Group Elects

Southern California Meter Association has elected new officers to the board of directors as follows:

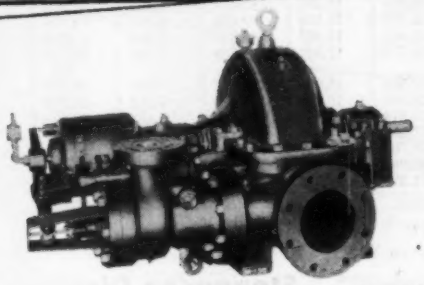
President, J. C. Greenewagen, Shell Oil Company; vice president, Edgar Valby, Richfield Oil Corporation; secre-

5 Ways

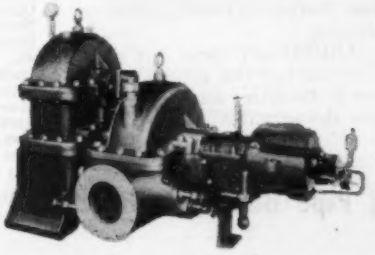
TO MAKE YOUR STEAM DO MORE WORK...

Power-Saving Worthington Turbines Cut The Operating Costs Of Mechanical Drives

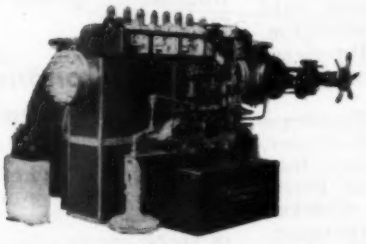
Worthington Turbines are built in all sizes and types — including straight condensing, straight non-condensing, extraction, mixed pressure extraction, low pressure and high back pressure — to meet the widest range of requirements. Steam or gas driven, for mechanical or generator drive, all are available with governors for constant or variable speeds. If desired, control devices can be incorporated in the governor.



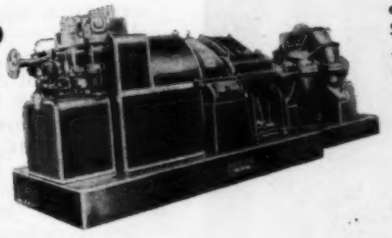
Single Stage. Sizes up to 1500 hp. Particularly adapted for driving all types of pumps, fans, small blowers and other auxiliaries where simplicity of construction and reliability are of prime importance.



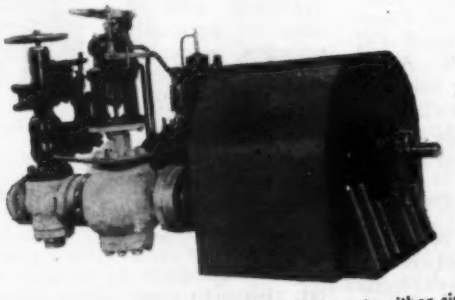
Single Stage With Integral Reduction Gear. Sizes up to 200 hp. A compact, sturdy, dependable unit with economical turbine operation. Especially suited for driving slow or moderate speed auxiliaries at low steam consumption.



Multi-Stage. Sizes up to 20,000 hp, and all types. Longer blade-life and more economical than single stage turbines especially on larger horsepowers and at slow or moderate speeds. Suitable for all kinds of pumps, blowers, compressors and other mechanical drives.



Multi-Stage With Separate Gear. Like all Worthington Multi-Stage Turbines, these are available in all types and are readily adaptable to special applications. Recommended for driving low speed equipment such as condenser circulating pumps, water supply pumps, etc.



High Back Pressure. Can be supplied in either single or multi-stage type for exhaust pressures up to 250 lbs.

For Low-Cost, Dependable Power. Check fully on the many advantages of Worthington Turbines. You'll discover what users the world over already know — that *there's more worth in Worthington*. Contact your nearest Worthington representative or district office, or write direct to *Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N. Y.*

WORTHINGTON

Steam Turbines

T9-S

A GREAT TEAM IN STEAM

THE MONTH . . .

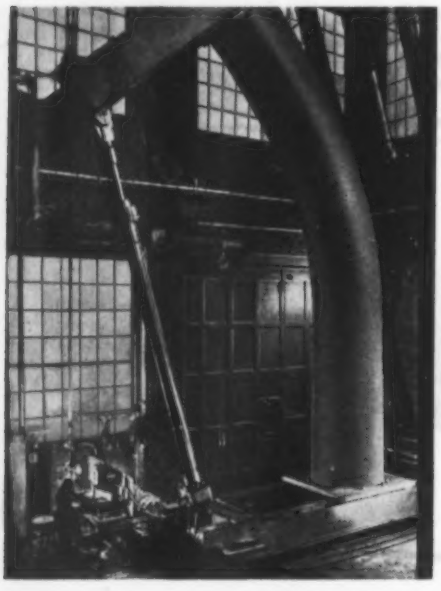
tary-treasurer, George H. Forster, Jr., The Texas Company; Auditor, Harry M. Kemmerer, Southern Counties Gas Company; and past president, Curtis G. Cortelyou of General Petroleum Corp.

Grant to MIT

Socony-Vacuum Oil Company, Inc., last month granted $250,000 to the Massachusetts Institute of Technology, Cambridge, for basic studies of nuclear fission and its engineering.

The grant, $50,000 per year for five years, will be utilized at the school's discretion to provide facilities and scientists for carrying out the actual work involved.

Big Pipe Bender



A major advance has been made in fabrication methods and results for large diameter thin-wall pipe bends. Heretofore, such bends have not been practical in diameters above 30 inches or in thin-wall sections, and bends fabricated from a number of mitered straight sections have been utilized. This new development will be especially important in certain refinery and process plant piping applications, since erosion difficulties encountered with pipe bends fabricated from a number of straight segments can be largely avoided.

The M. W. Kellogg Company perfected the bending process and apparatus which can handle pipe diameters up to 100 inches—"as large as will be required anywhere in the foreseeable future." The method bends pipe in the hot state under hydraulic pressure and is adaptable to small and large diameters, to thin and thick-walled pipe, and to short or long radius bends.

The value of the new process is said to be in the improved product, in the superior performance and reduced maintenance to be gained from uniform pipe contours both inside and out. The smooth even bend markedly reduces or eliminates entirely erosion and eddy currents due to sudden changes in direction or to sharp-cornered fillets which act as stress raisers. Because the pipe is bent hot and slowly cooled, stresses remain uniform throughout the bend, thereby minimizing the effects of stress corrosion.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,257	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	9,532	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,860	5,435	32,286	8,186	42,668
May 31	5,024	5,000	239,370	14,709	95,867	5,732	36,032	8,910	45,224
June 28	5,109	5,093	236,221	16,070	91,806	5,606	41,721	8,298	48,490
July 26	5,084	5,162	231,357	16,142	85,812	5,708	47,097	8,738	52,497
August 30	5,157	5,209	228,281	16,753	84,105	5,919	54,808	8,962	55,242
September 27	5,196	5,290	224,994	16,501	82,472	6,136	60,406	8,580	56,777
October 25	5,295	5,165	224,308	16,529	82,003	6,638	62,609	8,666	57,419
November 29	5,257	5,309	224,540	16,667	86,319	6,382	61,988	8,405	56,747
December 27	5,285	5,543	222,770	17,013	91,269	7,041	50,324	9,698	51,896
1948:									
January 31	5,318	5,434	221,663	15,986	102,973	7,690	40,580	9,141	50,830
February 28	5,387	5,463	220,507	15,796	111,040	7,963	33,836	8,824	49,206
March 27	5,377	5,324	222,314	15,783	112,991	7,682	30,717	8,854	48,334
April 24	5,415	5,517	221,652	16,515	111,128	6,831	34,237	8,877	49,572
May 29	5,452	5,715	221,703	17,827	107,185	7,054	38,641	9,508	55,140
June 26	5,494	5,674	222,081	17,938	104,178	7,200	45,166	8,858	58,812
July 31	5,455	5,718	*221,297	17,646	99,116	6,823	56,661	9,080	65,712

* July 24.

National Oil Policy Group Named by NPC

A temporary committee on nation oil policy, created at the request of Interior Secretary Krug to "restudy and supplement" policy recommendations of the Petroleum Industry War Council, held its first meeting July 28 in Washington.

A. Jacobsen of Amerada Petroleum Corporation heads the committee which includes:

Merle Becker, Independent Petroleum Association of America; Paul G. Blazer, Ashland Oil & Refining Company, Inc.; William R. Boyd, Jr., American Petroleum Institute; Stuart M. Crocker, Columbia Gas & Electric Corporation; Fayette B. Dow, National Petroleum Association; John B. Dressler, New Jersey Gasoline Retailers Association; R. G. Follis, Standard Oil Company of California; Earl Foster, Interstate Oil Compact Commission; J. Parks Gwaltney, National Oil Jobbers Council; B. A. Hardey, Shreveport, La.; C. L. Harding, Socony-Vacuum Oil Company, Inc.; George A. Hill, Jr., Houston Oil Company; Eugene Holman, Standard Oil Company (New Jersey); W. Alton Jones, Cities Service Company; John M. Lovejoy, Seaboard Oil Company; A. C. Mattei, Honolulu Oil Corporation; N. C. McGowen, United Gas Corporation; Frank M. Porter, Mid-Continent Oil & Gas Association; M. H. Robineau, Frontier Refining Company; W. G. Skelly, Skelly Oil Company; L. S. Wescoat, The Pure Oil Company; Robert E. Wilson, Standard Oil Company (Indiana) and Ralph T. Zook and Joseph E. Pogue, Chase National Bank.

G E Announces Changes

Harold F. Smiddy last month was named general manager of the chemical department of General Electric Company. Before coming to GE, Smiddy was a partner in Booz, Allen and Hamilton and was associated with Ebasco Services, Inc., Electric Bond and Share Company and West Penn Power Company.

George P. Lehmann has been named to the personal staff of Dr. Zay Jefferies, vice-president. Robert L. Gibson succeeds him as plastics division manager.

Stevenson Dies

Frederick A. Stevenson, 68, former president of American Car and Foundry Company, died suddenly July 29 in Wilmington, Delaware, while on his way to New York from Florida. He retired from active service with the company in May, 1947.

Chief Agronomist for Lion Oil Is Announced

Leroy Donald of Goodman, Miss., has joined the staff of Lion Oil Company as chief agronomist, his duties being to develop and promote more efficient methods of utilizing fertilizers, particularly nitrogen, as well as new and increased uses for plant foods. His program of work will be conducted in cooperation with officials of agricultural colleges, experiment stations, state extension services, etc.

Donald

Donald holds bachelor of science (general agriculture 1927) and master of science (1928) degrees from Mississippi State College. He did some teaching but in 1936, became associated with The Barrett Division of Allied Chemical and Dye Corporation as district agriculturist, rising to chief agronomist in October, 1945.

Fluid Cat Cracker Run Establishes New Record

The Fluid catalytic cracking plant of Tide Water Associated Oil Company at Avon, Calif., completed its record-breaking run of 610½ days in continuous operation on June 12, when it was shut down as planned for scheduled maintenance and repairs. This new record is 48 days more than the previous longest run of 562 days established by Cities Service Fluid Unit at Lake Charles, La.

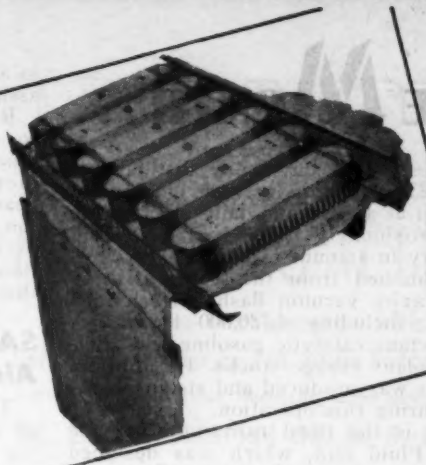
Since October 11, 1946, when this run was started, about 11 million barrels of

GLITSCH

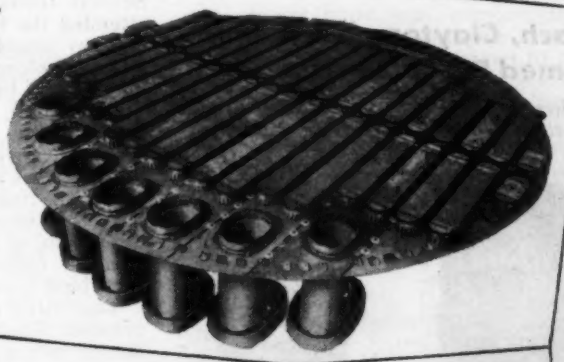
Bubble Trays
Bubble Caps
Rain Decks
Shower Decks
Accumulator Trays
Blank Trays

New Installations or Replacements

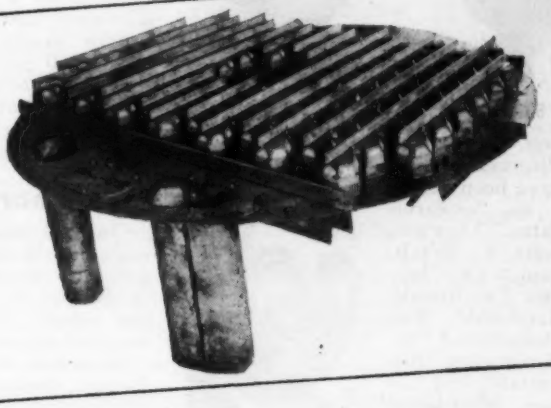
GLITSCH builds trays to fit. This one is only 28" for a 30" diam. tower. It is made of stainless steel, type 410, 12% chrome. Thickness is 12 and 14 gauge. Tray has blank end caps on the overflow side of the tray, with a notched overflow weir. Tray is entirely removable.



A 12% chrome alloy tray 12'-0" in diam. Decks and caps 14 gauge, supports 12 gauge. Seal pots on downcomers of tray. It is one of several replacing existing equipment in a unit having considerable corrosion of tower internals. Stainless alloy solved the tray corrosion problem.



A 9'-10" diam. tray for a 10'-0" I. D. tower. Material 12 gauge 12% chrome alloy. Note hexagon caps with hold-down bars running in direction of flow. Center manway is provided in tray for access to trays below.



GLITSCH Can Fabricate the Tray You Want!

By working with all suitable light-weight metals and alloys, trays can be designed to fit your refining problems, installed in the quickest time with the fewest men. Trained representatives from nearby offices will be happy to talk with you. No obligations whatever!

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"TRUSS-TYPE" BUBBLE TRAYS • BUBBLE CAPS • TOWER INTERNALS

THE MONTH . . .

fresh feed as heavy waxy distillate of about 23° API gravity were charged to the unit at an average daily charge rate of approximately 18,000 barrels. Liquid recovery in amount of 10,550,000 barrels was obtained from this exceedingly low gravity vacuum flashed fresh feed charge, including 4,720,000 barrels of high octane catalytic gasoline and alkylation plant charge stocks. In addition, dry gas was produced and steam generated during this operation.

This is the third turnaround of the Avon Fluid unit, which was designed by Universal Oil Products Company, erected in 1944 by C. F. Braun and Company and initially placed on stream December 29, 1944.

Beach, Clayton, Macdonald Named Research Associates

Three scientists at the Richmond laboratories of California Research Corporation, a Standard of California subsidiary, have been designated as "research associates." They are, Dr. John Y. Beach, Dr. James O. Clayton and Dr. Ronald T. Macdonald. The new designation "research associate" has been established "to further emphasize the research company's policy of recognizing outstanding scientific ability and accomplishments among its laboratory technical personnel," it was explained.

Beach

Clayton

Macdonald

Dr. Beach is the company's technical specialist and consultant in spectrography and X-ray and electron diffractions, Dr. Clayton is an expert in the field of compounded lubricating oils while Dr. Macdonald's work is in the research company's greases and industrial lubricants division.

Monsanto Offers Teachers Industrial Plant Training

A program which will permit university and college faculty members in chemical engineering to gain a full year's on-the-job experience in the chemical industry was announced last month by Monsanto Chemical Company.

Teachers chosen for participation in the program will be paid the salary ordinarily paid for comparable jobs within the company, and their moving expenses to and from the plant to which they are assigned will also be paid by Monsanto.

Robert V. Andrews, assistant professor in the Department of Chemical Engineering, of Texas A. & M. will join Monsanto September 1, 1948, for one year's service at the company's Anniston, Ala., plant. Teachers will be expected to resume their faculty affiliations for one year at the conclusion of their Monsanto service.

SAE Sessions Told About Aluminum in Automobiles

The summer meeting of the Society of Automotive Engineers was held during June in French Lick Springs, Ind., with the attention of engineers directed particularly to ways and means of improving the performance, parts, and equipment of modern motor vehicles. Several thousand automotive engineers attended the technical sessions.

Many engineering problems must be solved before the American motorist may expect to use vehicles made largely of aluminum, the meeting was told by D. F. Toot, of Chrysler Corporation, Detroit. Currently, a 10 percent reduction in gross weight would provide substantial savings for the owner, Toot said, but the present trend suggests selective utilization of aluminum, steel, and cast iron for purposes and parts for which each best is suited.

Toot cited estimates to show that the greatest possible utilization of aluminum would increase the volume of material used about 45 percent, with attendant increased costs. He estimated the resultant saving in weight as approximately 50 percent, explaining that the consumer thereby might gain through the use of smaller engine, wheels, and brakes, as well as through savings in taxes, shipping costs, and fuel.

Fifty-Year Veteran

Only 14 years old when he started to work in the can house, Fred Ehlers, a general foreman at the Whiting refinery of Standard Oil Company (Indiana), last month celebrated conclusion of 50 years of service.

In honor of the occasion Dr. M. G. Paulus, vice president in charge of manufacturing, awarded Ehlers a gold watch. Ehlers will retire on company annuity August 20, when he will be 65 years old.

Ehlers' son, Howard, works at the Stanolind power station and another son, Albert, is with the engine laboratory at Whiting.

Gets $2100 for Idea

Theo Northcutt, Avon refinery employe, Tide Water Associated Oil Company, received the company's coordinating Committee's award of $1500 for the most meritorious suggestion submitted during the year 1947. The suggestion first earned him an initial award of $100, then $500 as the outstanding suggestion made by Western Division employees, and in climax the special capital award of $1500.

Nash Appointed

Rodney M. Nash has been appointed general counsel of Pan American Petroleum & Transport Company. He succeeds Thomas E. Sunderland, now general counsel for Standard Oil Company (Indiana).

Barker With Armistead

John W. Barker, formerly of Houdry Process Corporation and Foster Wheeler Corporation of New York has joined the engineering staff of George Armistead, Jr., consulting chemical engineer of Washington, D. C. A graduate of Massachusetts Institute of Technology in 1941, Barker has specialized for several years in the design and engineering of refinery process units, as well as the supervision of pilot plant research. He will serve in a general engineering capacity in the various services rendered by the Armistead organization.

Barker

Brewster Heads New Unit

Benjamin Brewster has been appointed to the newly-created position of manager of the technical service division of Ethyl Corporation Research Laboratories, Detroit. This division is the liaison group between the Ethyl Laboratories and oil company research departments, and automotive and farm equipment manufacturers.

Brewster, who also will continue as a member of the technical representatives group, joined Ethyl Corporation more than 21 years ago.

Peterson Is Promoted By California Standard

Appointment of E. R. Peterson as a vice president of Standard Oil Company of California, was announced last month by T. S. Petersen, president of Standard.

For the past several years, Peterson has served as secretary of the company's executive committee and has performed confidential analysis for the executive staff. He joined Standard in 1923 and served in the Marketing Department until 1936, when he was attached to the executive staff as a general assistant.

Koach Elected LPG Head

Newly elected president of the Liquefied Petroleum Gas Association at its annual meeting is K. H. Koach, Green's Fuel, Inc., Sarasota, Fla. He succeeds T. H. Ransome of The Ransome Company, Emeryville, Calif.

Parker Awarded Degree

Philo W. Parker, chairman of the board of Standard-Vacuum Oil Company, was awarded an honorary doctor of laws degree by Colgate University at Hamilton, N. Y., on June 14. He is a graduate of Colgate, class of 1912, and a member of Phi Beta Kappa.

GE Promotes Jackson

Roger W. Jackson has been named district sales manager of General Electric Company Chemical Department's East Central District with headquarters in Cleveland, Ohio. He takes his new post after more than three years as district representative at the Pittsburgh office.

SCIENCE and TECHNOLOGY ABSTRACTS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

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Petroleum Refiner by The Leslie Laboratories
Traver Road, Ann Arbor, Michigan, under supervision of
DR. E. H. LESLIE and DR. H. B. COATS

Fundamental Physical and Chemical Data

The Vapor Pressures and Some Related Quantities of Pentane-1 0 to 200°. H. O. DAY AND D. E. NICHOLSON with W. A. FELSING. *Jour. Am. Chem. Soc.*, **70** (1948) pp. 1784-5.

The increasing importance of the olefinic hydrocarbons has made further data on the thermodynamic properties of these hydrocarbons desirable. The present paper is one in a series from the laboratory of the University of Texas on the properties of the hydrocarbons. The densities of liquid pentene-1 under its vapor pressure were determined from 0 to 50° C. Vapor pressure of pentene-1 was determined from 0 to 200° C. The heats of vaporization were calculated and are reported at 0 to 30.07° C.

Densities and Liquid-Vapor Equilibria of the System Ethanol-Isooctane (2,2,4-Trimethylpentane between 0 and 50°. CARL B. KRETSCHMER, JANINA NOWAKOWSKA AND RICHARD WIEBE. *Jour. Am. Chem. Soc.*, **70** (1948) pp. 1785-90.

The investigation reported is part of the systematic program at the Northern Regional Research Laboratory to determine certain physical properties of ethanol-hydrocarbon systems. The densities of ethanol, isooctane and isooctane-ethanol solutions were measured at 0, 25 and 50° C. Equations giving the density of ethanol and isooctane as a function of temperature are presented. Volume expansion on mixing is found to increase rapidly with temperature. Static vapor pressures at 0 and 25° and liquid-vapor equilibria at 25 and 50° C. were determined. Satisfactory agreement was obtained with calculated values. Activity coefficients were calculated using the Van Laar equation and approximate reproduction of the experimental data was obtained.

Vapor Pressure-temperature Temperature Relations Among the Branched Paraffin Hydrocarbons. HARRY WIENER. *J. Phys. & Colloid Chem.*, **52** (1948) pp. 425-30.

The author has extended the application of his equation relating the difference in normal boiling point between a branched-chain paraffin and its straight-chain isomer to give the difference in boiling point between the isomers at any pressure from 57 to 780 mm. of mercury. The average deviation between observed and calculated boiling point for 466 points for which data were available was ±0.17° C.

Viscosity Data and Relations of Normal and Isoparaffins. G. W. NEDERBRAFT AND J. W. M. BOELHOUWER. *Physica* **13** (1947), pp. 305-18.

The viscosities of several of the higher paraffins were studied, using a method depending on the time of descent of a small needle of glass in a capillary filled with the liquid. The effects of chain length and of chain branching were studied. The conclusion was reached that the shortening of the molecule from branching decreases viscosity, but that the accumulation of C atoms near the tertiary or quaternary C atom increases the viscosity. This latter effect is smaller if the tertiary or quaternary C atom is closer to the center of the molecule. Effect of the shortening then predominates and can be calculated.

Average Length and Radius of Normal Paraffin Hydrocarbon Molecules. WM. J. TAYLOR. *J. Chem. Phys.*, **16** (1948), pp. 257-67.

Formulas previously published for the average length and radius of long-chain molecules with restricted internal rotation have been applied to a model of the normal paraffin hydrocarbons. The central barrier for rotation about the C-C single bond was compounded of the threefold component plus a smaller onefold component that served to stabilize the transfiguration of three successive bonds. Values for a wide range of parameters were calculated and the most probable values of the parameters applicable to the normal paraffins are discussed. The effect of steric hindrance is considered, and the author regards it as probable that the calculated values are low because of the neglect of steric hindrance.

Ultrasonic Velocity in a Series of 1-Olefins. R. T. LAGEMANN, D. R. MCMILLAN, JR., AND MARTHA WOOLSEY. *J. Chem. Phys.* **16** (1948), pp. 247-9.

The ultrasonic velocity was measured at 10° to 30° C. for 1-heptene, 1-octene, 1-nonene, 1-decene, 1-hendecene, 1-tridecene, and 1-pentadecene. The density and refractive index were measured. From the measurements made, values of molecular sound velocity, adiabatic compressibility, and molecular refractivity were calculated. The ultrasonic velocity varies linearly with temperature, whereas the molar constant, $MV^{0.6}/d$, remains substantially constant. The constant is found to be strictly additive for the hydrocarbons studied.

Chemical Compositions and Reactions

Isomerization of Saturated Hydrocarbons. V. The Effect of Cyclohexene Upon the Isomerization of Methylcyclopentane and Cyclohexane. HERMAN PINES, B. M. ABRAHAM and V. N. IPATIEFF. *Jour. Am. Chem. Soc.*, **70** (1948), pp. 1742-6.

The investigation reported is a continuation of studies in which it was found that the isomerization of *n*-butane to isobutane takes place in the presence of aluminum chloride-hydrogen chloride only in the presence of traces of olefins. Reversible isomerization of methylcyclopentane to cyclohexane in the presence of aluminum bromide-hydrogen bromide as the catalyst was studied using high vacuum technique. Under certain controlled conditions methylcyclopentane does not isomerize to cyclohexane unless cyclohexene or cyclohexyl bromide in amounts of about 0.05 mole percent, or higher, are present. Effect of olefins, hydrogen bromide, and aluminum bromide concentrations upon the isomerization of methylcyclopentane was studied. A mechanism of the isomerization is proposed.

"Low-Temperature" Oxidation of Higher Hydrocarbons at Atmospheric Pressure. G. FRIEDLANDER AND L. GRUNBERG, Dr. Rosin Industrial Research Co. *Nature* **161** (1948), pp. 360-1.

The behavior of n-heptane and of a mixture of n-heptane and benzene was studied in ignition experiments in a Moore-type apparatus at 300-500° C. and atmospheric pressure. At temperatures under 400° C., the "pre-ignition pulse" could be observed by the expulsion of vapors from the apparatus. Above 400° C., the delay between pulse and ignition was too short to be observed. Below 316° C., no ignition could be observed, yet the pulse occurred down to 300° C. With the heptane-benzene mixture, ignition above 425° C. occurred by a single-stage mechanism. Between 305 and 370° C. the pressure pulse occurred without being followed by ignition. Gas samples corresponding to different stages of the reaction were analyzed. In general, a peroxide maximum was followed by an aldehyde maximum, indicating that aldehydes are

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products of the decomposition of peroxides. The mechanism of the reaction is discussed. The addition of tetraethyl lead to n-heptane did not suppress the pressure pulses, but prevented ignition at temperatures at which it would normally occur with pure heptane.

Methylation of Olefins with Methyl Chloride. VERLE A. MILLER AND W. G. LOVELL. *Ind. Eng. Chem.*, **40** (1948), pp. 1138-50.

Because of the increased interest in high antiknock fuels for engine development fostered by the necessities of wartime, the large scale production of pure triptane (2,2,3-trimethylbutane), one of the fuels that possesses the highest degree of freedom from knock, was undertaken. A general reaction is described for methylating olefins to produce highly branched hydrocarbons. This reaction was used to produce triptane by hydrogenating the methylated product from trimethylethylene. Production was effected on three scales: first, in the laboratory, second, on a semi-pilot plant, and third, in a large pilot plant to produce tank car lots. The present paper considers primarily the laboratory and semi-pilot plant studies. Data are presented in considerable detail in tabular and graphical form and a bibliography of 24 references is included.

The Synthesis of Toluene by the Friedel-Craft's Reaction. D. V. N. HARDY. *Jour. Soc. Chem. Ind.*, **67** (1948), pp. 81-2.

Toluene was produced from benzene and methyl chloride in the presence of aluminum chloride, to the extent of 0.9-1.0 mol. per mol. of aluminum chloride. Under special conditions a yield of 1.6 mol. was obtained. Of the benzene consumed, up to 59 percent appeared as toluene, and up to 37 percent of the methyl chloride was utilized in the desired way. By conducting the reaction under pressure, benzene conversion can be raised to 63 percent, and the methyl chloride conversion to 43 percent. If hydrogen chloride is added under pressure, somewhat higher conversions are obtained. The presence of iron in the reaction mixture was not found to be beneficial. Aluminum chloride cannot be separated from the reaction product by distillation. Vacuum distillation of the crude reaction product yields liquid and solid addition compounds. Xylene can be partially converted into a mixture of toluene, trimethylbenzene and higher-methylated benzenes, by treatment with aluminum chloride and hydrogen chloride in an autoclave at 80° C. In addition to toluene, the methylated compounds formed are mainly xylene, trimethylbenzene and tetramethylbenzene or durene.

The Use of Zinc Alkyls in the Preparation of Hydrocarbons with a Quaternary Carbon Atom. F. R. BUCK, B. B. ELSNER, E. J. FORBES, S. H. MORRELL, J. C. SMITH, AND E. R. WALLSGROVE. *Jour. Inst. of Petroleum* **34** (1948) pp. 339-69.

The synthesis of several hydrocarbons containing quaternary carbon atoms was undertaken as an extension of an investigation started years ago by the Anglo-Iranian Oil Company. For these syntheses the zinc-alkyl technique was developed to give high yields. Among the hydrocarbons prepared were: 2:2-dimethylpropane (*neo*pentane), 2:2-dimethylpentane, 3:3-dimethylpentane, 2:2-dimethylhexane, 3:3-dimethylhexane, 2:3:3-trimethylpentane, 3-methyl-3-ethylpentane, 2:3:3-trimethylhexane, 3:3-diethylpentane (*neo*nonane); 3:3-diethylhexane; 3-methyl-3-ethylheptane; 1:1-dimethyl*cyclo*hexane; 1-methyl-1-ethyl*cyclo*hexane; 1-methyl-1-propyl*cyclo*hexane; 1:1-diethyl*cyclo*hexane; and 1:2-diethyl*cyclo*hexane. Some of the side reactions are briefly described that occur when using zinc alkyls, and comments are made on a preliminary investigation of certain of the side reactions. A bibliography of 58 references is included.

Manufacture: Processes and Plant

Radiative and Convective Heat Transfer Rates Pertaining to Heating Processes. JACK HUEBLER. *Ind. Eng. Chem.*, **40** (1948), pp. 1094-98.

Definite analyses of the effective value of convection and radiation in heat transfer are difficult to perform because of the inseparable character of the two phenomena. The author seeks to compare, under theoretically ideal conditions, the effect of radiation and convection heating simultaneously applied to a plate. For this purpose an equivalent radiation "heat transfer coefficient" is utilized, and although the differential equations involved are insoluble, graphical methods of solution were applied. The results reveal the contribution made by convection alone to the total heat transfer attainable under assumed conditions and its ratio to heat transfer by radiation.

Condensation of Water, Styrene, and Butadiene Vapors. DAVID A. EDWARDS, CHARLES F. BONILLA, AND MARIO T. CICHELLI. *Ind. Eng. Chem.* **40** (1948), pp. 1105-12.

Condensation of water, styrene, and butadiene vapors, and of water-styrene and water-butadiene mixtures at or near their constant boiling compositions was studied in a 1-inch diameter and 8-inch long vertical condenser. Wall thermocouples permitted the calculation of the film coefficients of heat transfer; 300 runs were made. Pressure ranged from 14 mm. absolute to atmospheric pressure for styrene, and 34 to 100 psia. for butadiene. Coefficients for water averaged 6 percent above the Nusselt theory and for butadiene 40 percent above. For styrene they averaged 129 percent higher than theory. Assuming the vapor mixtures were at the equilibrium composition and the condensate film comprised the organic component alone, the Nusselt theory was found to correlate the results with two immiscible components more consistently than other available relationships. Deviations were in the direction of conservative design. Coefficients for the system styrene-water averaged 43 percent higher and for butadiene-water 34 percent higher than theory. Film Reynolds numbers ranged from 9 to 1460.

Petroleum Chemical Detergents. MARCUS SITTENFIELD. *Chem. Eng.*, **55**:6 (1948), pp. 120-2.

Synthetic detergent production is now one of the major industries in this country from the standpoint of tonnage. It is estimated that 700 to 800 million pounds will be made during 1948. Of this total, 60 to 70 percent will be derived largely from petroleum products. Of the detergents derived from petroleum hydrocarbons, alkyl phenol sulphonates, alkyl sulphonates and the alkyl aryl sulphonates are the most common. Benzene and a kerosine distillate fraction are the usual commercial starting points for the production of alkyl aryl sulphonate detergents from petroleum. The boiling range of the straight-chain hydrocarbons is usually between 185 and 290° C. This fraction is chlorinated and the monochlor compound is reacted with the aromatic compound by means of the Friedel-Crafts reaction. Aluminum chloride is the commonest catalyst. The alkyl aromatic compound is then sulphonated. The sulphonated material is drowned in ice water and neutralized with sodium hydroxide. Detergent properties of the alkyl aryl sulphonates vary with the number of carbon atoms in the alkyl chain. Production of long chain hydrocarbon compounds by polymerization is briefly considered. The cost of a plant to make 30,000 pounds per 24-hour day of 60 percent active material is approximately between $75,000 and $85,000. The major part of this cost is the drying equipment needed. The cost of the detergent is estimated at approximately 14 cents per pound.

Telecommunications in the Petroleum Industry. Z. FRIEDBERG. *Jour. Inst. of Petroleum*, **34** (1948), pp. 309-30.

The author describes modern communications systems as used in the operation of oil companies, as for example, by pipe lines, and in oil fields, refineries, pumping, loading and miscellaneous activities. The primary considerations in deciding on the equipment for an oil company are, first, reliable and efficient operation and second, simplicity. Types of communication considered are radio, ultra-short wave, and land-line communication. The system of Iraq Petroleum Company's communication service is briefly described.

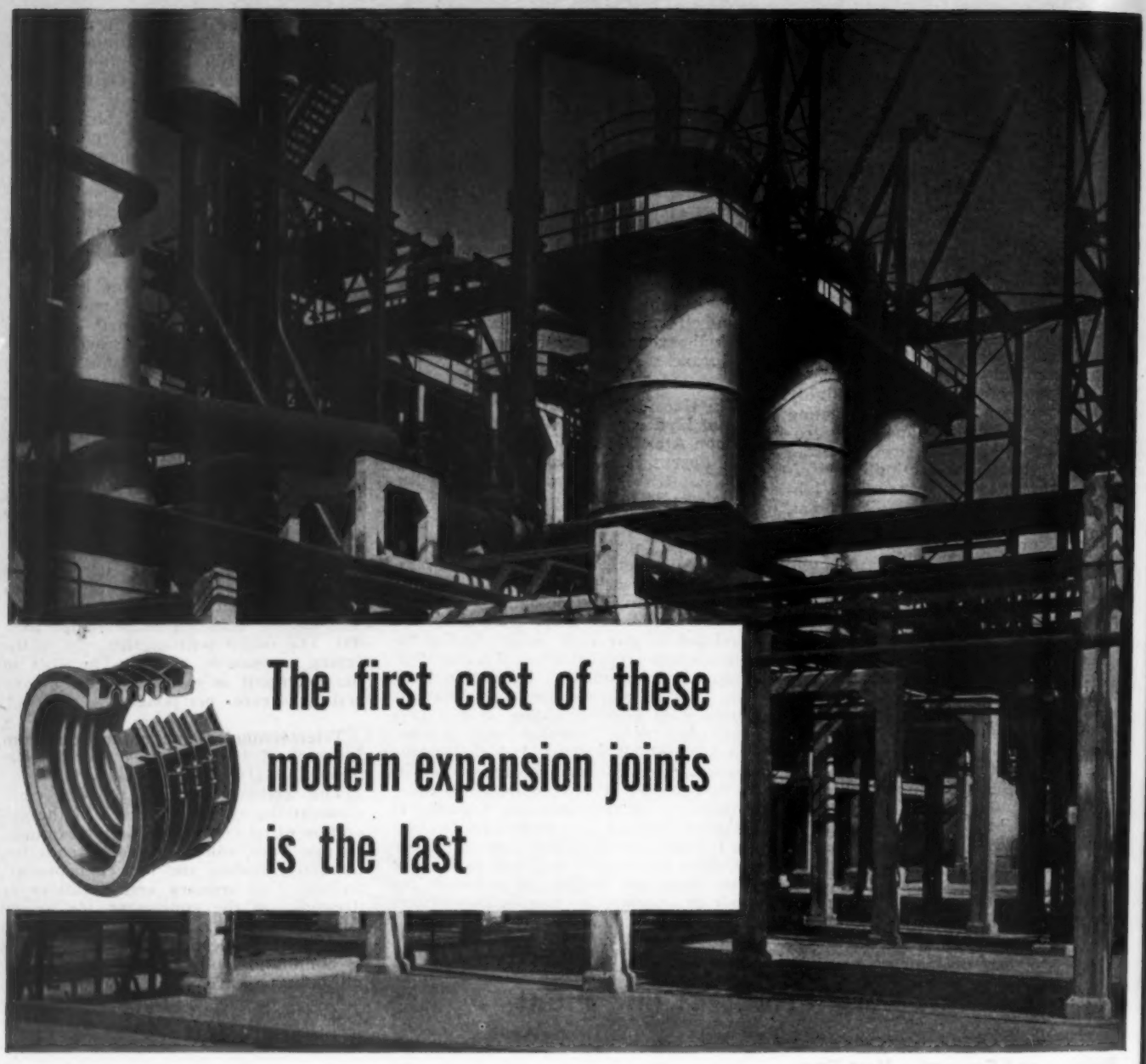
Unsteady-State Heat Transfer Between Air and Loose Solids. G. O. G. LOF AND R. W. HAWLEY. *Ind. Eng. Chem.* **40** (1948), pp. 1061-70.

Few data are available for the design of equipment employing heat transfer from a flowing fluid to a bed of loose solids. In the study reported, data in the form of unsteady-state heat transfer coefficients from air to a bed of granitic gravel are presented. The size of the gravel employed ranged from 4-mesh to 1.5 inches; air rates 12 to 66 standard cubic feet per minute per square foot of cross-sectional area; and entrance air temperatures in the range of 100 to 250° F. The results can be correlated by the equation

$$h = 0.79\left(\frac{G}{D}\right)^{0.7}$$

in which G is the air flow rate in pounds per hour per square foot of bed cross section, and D is the equivalent sperical diameter of the particles in feet. The change in temperature of the entering air had no appreciable effect on the coefficient.

Heat Transfer to Granular Materials. M. S. BRINN, S. J. FRIEDMAN, F. A. GLUCK-



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PACKLESS CORRUGATED EXPANSION JOINTS

ET AND R. L. PIGFORD. *Ind. Eng. Chem.* **40** (1948), pp. 1050-61.

Few design data are available in the literature with respect to equipment for transferring heat to or from granular materials. One method of performing this operation comprises passing the granular material, as a settled bed downward through vertical jacketed tubes. Effective thermal conductivities, as calculated from heat transfer data for beds of granular materials moving downward through vertical steam-jacketed tubes, assuming rodlike form, agreed closely with conductivities measured in separate experiments with stationary beds. Rodlike flow was visually observed for Ottawa sand by the use of a split-tube technique. Theoretical equations were developed and design charts prepared for the general case of counter-current heat transfer to a material in rodlike flow in a tube. Equations have also been developed for the case of parallel flow. A bibliography of nine references was included.

Corrosion in Isomerization of Light Hydrocarbons. N. FRAGEN, C. W. NYSEWANDER AND W. R. HERTWIG. *Ind. Eng. Chem.*, **40** (1948), pp. 1133-8.

The liquid phase isomerization of light hydrocarbons by aluminum chloride-hydrocarbon complex cat[alysts] corrosion causes penetration of ca[rbon] steel from 1 to 5 inches per year in the reactor, and up to 15 inches per year at points of high turbulence. The lines and vessels handling the products of reaction exhibit penetration rates about one tenth of those in the reactor. Corrosion rates vary with the catalyst turbulence, hydrogen chloride concentration, catalyst activity, and the temperatures. Attacks by aluminum chloride complex has been studied on the laboratory and commercial scale, and several means have been found for safeguarding steel equipment. The most successful of these involves the use of gunited Lumnite cement reactor liners and Hastelloy B reactor nozzle, flange, and valve protection. The article is illustrated with pictures to show the effect of corrosion of time.

Phillips Butane Dehydrogenation Process, Special Plant Investigations. GEORGE H. HANSON AND HARRISON L. HAYS. *Chem. Eng. Progress,* **44** (1948), pp. 431-42.

The authors describe a process for the catalytic dehydrogenation of normal butane to butylenes. Historical background of the development of the process is briefly given. The work led to the development of the process on which Plains Butadiene Plant was based. This plant was started in July, 1943, and has been in practically continuous operation since that time. The catalysts used are chromia-alumina and they are prepared in ⅛ by ⅛ inch cylindrical pellets. The reaction is usually effected at temperatures of about 1100° F., and at pressures slightly above atmospheric with space velocities of about 850. The life of the catalyst is more than 100 days. The process is described in some detail, flow sheets are presented and the effects of the chief reaction variables are discussed. The results of a detailed investigation of the performance of the individual "harps" in a reactor are reported. A plant study of materials of construction for catalyst tubes is discussed. A bibliography of five references is included.

Butane Dehydrogenation-Pilot-Plant Investigations. K. HACHMUTH AND G. H. HANSON. *Chem. Eng. Progress,* **44**:6 (1948), pp. 421-30.

The paper reports the results of pilot-plant studies of the catalytic dehydrogenation of normal butane to normal butylenes. Several catalysts and catalyst tube materials were investigated. Results of spectrophotometric analyses of the C_4 fractions to show the concentrations of the isomeric butylenes and butadiene in the catalyst tube effluent. The ranges of operating conditions studied were as follows:

Catalyst	Number of Cycles Studied	Temperature °F.*	Space Velocity
A.....	485	1000–1300	200–2200
B.....	367	1050–1150	500–1300
C.....	467	990–1090	500 2000

* Average external catalyst tube wall temperature.

Variation of the reaction during the dehydrogenation period is illustrated, and the effect of operating conditions on coke deposition is discussed. Results of the studies of the effect of variations of oxygen concentration and water concentration in the regeneration gas on the catalytic dehydrogenation reaction are included. A bibliography of nine references is given.

Review of Development of Processes for Synthesis of Liquid Fuels by Hydrogenation of Carbon Monoxide. H. H. STORCH. *Chem. Eng. Progress,* **44** (1948), pp. 469-80.

The author reviews the development of processes for the synthesis of liquid fuels by hydrogenation of carbon monoxide. The early work, 1923-1937, of F. Fischer and his associates is followed by a more detailed discussion of process development work in Germany and in the United States since 1938. Data are presented in tabular form that facilitate comparisons of operating temperatures, pressures, space-time yields, product distributions, and steel requirements. The latter part of the paper contains a description of processes closely related to the Fischer-Tropsch synthesis, namely, the Synol, OXO, and isoparaffin syntheses, and a discussion of the problem of carbon deposition on iron catalysts. A bibliography of 29 references is included.

Heat Transfer to Boiling Styrene and Butadiene and Their Mixtures with Water. CHARLES F. BONILLA AND ARTHUR A. EISENBERG. *Ind. Eng. Chem.* **40** (1948), pp. 1113-22.

The investigation shows that in the boiling of mixtures of components that are not mutually soluble the necessary temperature difference, based on the equilibrium temperature, will be appreciably larger than for either component alone at the same rate of heat transfer. In the boiling of relatively shallow depths of mixtures of insoluble liquids, considerable superheating of the mixture can be expected, in contrast to the boiling of two-phase mixtures of partially soluble liquids. If the liquid phase of lower density has a lower boiling point, boiling of the denser phase may not occur until high heat transfer rates are reached, as the heat transfer takes place at lower rates by natural convection. At a low rate of boiling the lighter layer will not mix sufficiently with the denser layer to be carried down to the heating surface, and at the boiling rate at which this starts a discontinuity in the Δt value will be observed.

Products: Properties, Utilization and Analysis

Determination of Acetylene in Gas. J. A. SHAW AND ELTON FISHER. *Anal. Chem.*, **20** (1948), pp. 533-6.

A method is described for determining acetylene in gas by scrubbing the gas with a strong solution of silver nitrate and then precipitating and weighing the acetylene complex as $Ag_2C_2.AgNO_3$. In brief, the method comprises scrubbing the gas with 35 percent silver nitrate solution, usually containing ferric nitrate, diluting this solution highly with water, and filtering, washing, drying, and weighing the residue. The procedure permits the quantitative removal of acetylene from a flowing gas stream, which avoids the reducing effect of hydrogen upon silver nitrate and is essentially non-hazardous. As the size of the sample can be large, the method can be used for determining very low concentrations of acetylene. The accuracy of the method is limited only by the mechanical considerations involved in gravimetric analyses.

Properties and Uses of Alkanesulfonic Acids. W. A. PROELL, C. E. ADAMS AND B. H. SHOEMAKER. *Ind. Eng. Chem.*, **40** (1948), pp. 1129-32.

Although a few of the alkanesulfonic acids of high molecular weight have been produced for some time on a commercial scale for use as surface active agents, alkanesulfonic acids of lower molecular weight have remained laboratory curiosities. Recently the authors developed a catalytic process for large scale production of either individual or mixed alkanesulfonic acids. The paper describes the preparation of C_1 to C_4 acids, summarizes published information on their physical and chemical properties, records new information on these properties, and suggests potential uses of the compounds.

Detergent Oils for Aircraft—On Detergent Oils for Light Plane Engines. Based on discussions by W. V. HOOLEY, H. R. KEMMERER AND E. F. H. PENNEKAMP. *S.A.E. Journal,* **56** (1948), p. 19.

Current difficulties with light aircraft engine detergent oils are like those encountered with any other new product. Most additive oils were designed for heavy-duty ground service and cannot be used indiscriminately in aviation engines. The need for detergents in light aircraft oils depends on the design of the engine, and on operation and maintenance practice. The purging action of detergent oils when used in engines formerly operated on nondetergent types may loosen previously-formed deposits. This can be serious in relatively cold-

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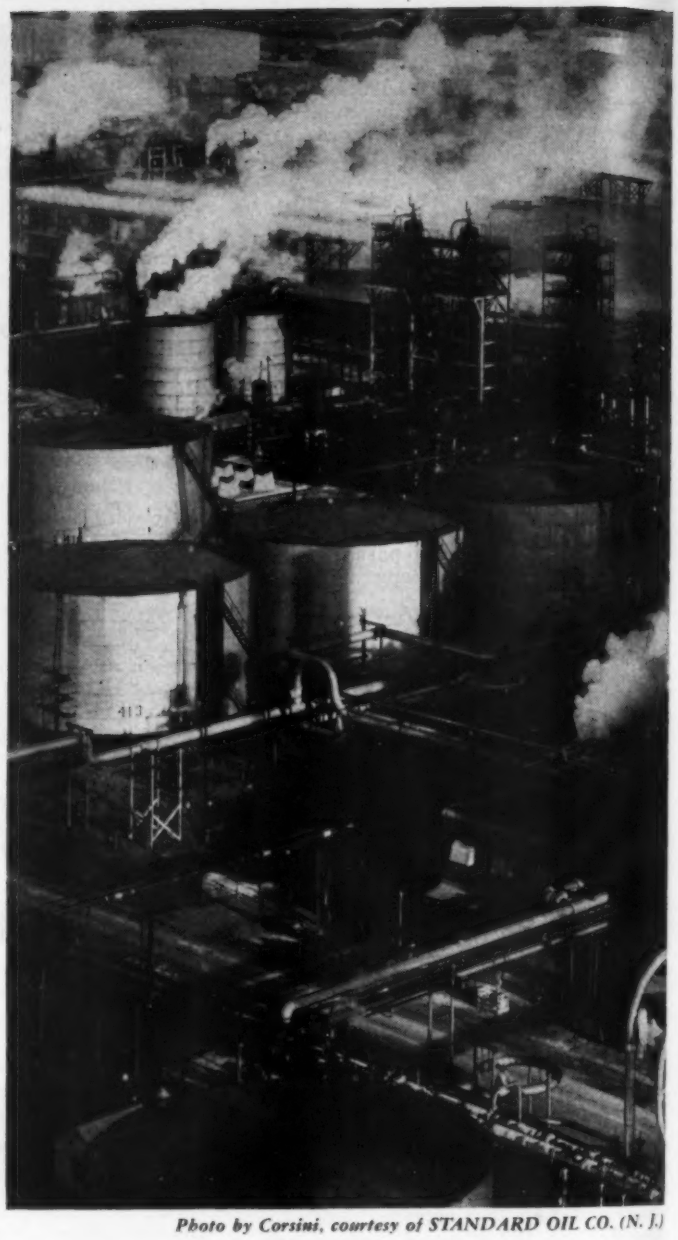

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An Accurate Microviscometer. ERICA GLYNN AND L. GRUNBERG. *Jour. Inst. of Petroleum*, **34** (1948), pp. 331-8.

A microviscometer is described, the operation of which is based on the rate of flow of the liquid from a reservoir under a constant applied pressure into an empty capillary. For liquids having viscosities lying between 1 and 100 poises, a capillary radius of 0.01 cm. would give accurate values and 10 to 15 mg. of material was needed. For liquids of higher viscosity, that is, 100 to 1000 poises, larger capillaries, of radius up to 0.03 cm., were used with corresponding increase in the weight of material 40 to 80 mg. The accuracy obtainable by the use of the instrument is of the order of 0.5 percent. The apparatus is described in some detail and the calibration method that can be used is considered. A bibliography of seven references is included.

Micro-determination of Sulfur in Organic Compounds. AL STEYERMARK, ESTHER BASS AND BELLA LITTMAN. *Anal. Chem.*, **20** (1948), p. 587.

A micro-method for determining sulfur is presented that employs the Carius combustion followed by titration of the resulting sulfate with barium chloride. The tetrahydroxyquinone indicator method of Ogg, Willits, and Cooper is used. Tables are given showing the calculated and found percentages of sulfur. These are in close agreement. A bibliography of six references is included.

Spectroscopic Determination of Cyclopentadiene and Methylcyclopentadiene. J. S. POWELL AND J. C. EDSON. *Anal. Chem.*, **20** (1948), pp. 510-11.

An ultraviolet spectroscopic method is described for determining cyclopentadiene and methylcyclopentadiene in the presence of each other. The sample is first depolymerized by passing it through a heated tube in order to get monomers. The ultraviolet absorption of the depolymerized sample is determined at two different wave lengths, from which data the composition of the sample can be calculated. Aromatic hydrocarbons and conjugated diolefins interfere with the procedure. The sample can, however, be dimerized, in which event the cyclopentadiene and methylcyclopentadiene are converted to dimers that have little ultraviolet absorption. A blank ultraviolet absorption value can then be obtained that corrects for the interferences, if the concentration of interferring substances is small compared to the concentrations of cyclopentadiene and methylcyclopentadiene.

Laboratory Evaluation of Oil Deterioration R. G. LARSEN. *Anal. Chem.*, **20** (1948), pp. 547-55.

In general, deterioration of oils is associated with oxidation, although cracking and volatilization should not be ignored. Three types of oxidation products are recognized: sludge, acids, and saponifiable substances. Sludge or high-molecular-weight products can cause filter-screen clogging, oil-passage plugging, ring sticking, and lacquer deposition. Acids are objectionable in the engines if corrodible bearing metals are present; in turbine oils they may lead to emulsion formation and in transformer oils to impairment of insulation. Saponifiable materials may sometimes be fairly innocuous, but most of them lead to a viscosity increase of the oil, while some may act as catalysts for further oxidation or bearing corrosion. The author gives detailed consideration to the physiochemical variables involved in the deterioration of engine, turbine, and transformer oils. It is possible thus to establish the conditions most efficient for laboratory tests. Behavior of engine lubricants in the ring-belt area can never be studied in tests designed for measuring crankcase-oil stability but the investigation requires specially adapted high-temperature experiments. Limitations are discussed as well as difficulties in correlating test results with field experiences. It is concluded that the laboratory methods should be employed not so much to predict the useful life of an oil as to provide a relative rating and also information as to the fundamental chemical nature of given oils. A bibliography of 47 references is included.

BOOKS

The varied applications of molybdenum as an alloying element are described in **"Molybdenum: Steel, Irons, Alloys,"** a book by R. S. Archer, J. S. Briggs and C. M. Loeb, Jr., and published last month by Climax Molybdenum Company, 500 Fifth Avenue, New York 18. The book covers a wide range of materials from wrought to cast steels and from cast iron to nonferrous alloys. The major emphasis has been placed on the presentation of the fundamentals that must guide all engineers, designers and metallurgists in their section of the most suitable materials for a given application.

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"Communism or Capitalism" is published and available from National Foremen's Institute, Inc., Deep River, Conn. Prices of this manual vary as to quantities ranging from 15 cents per copy for orders of less than 50 to 10 cents per copy in quantities of 3001 or more.

The medical department of Socony-Vacuum Oil Company, Inc., New York, has prepared a booklet, **Preserve Your Health,** by A. E. Hoag, M.D., F.A.C.S., medical director of the company, that has been mailed to the homes of 30,000 employes. The booklet was prepared for the health guidance of the company's employes and their families and contains basic information on such subjects as general health, athlete's foot, summer hazards, proper diet, peptic ulcers, flat feet, Socony-Vacuum health program, common colds, heart disease, hay fever, appendicitis, influenza, and tuberculosis.

Copies of the booklet can be obtained by writing to the company at 26 Broadway, New York 4, New York, publicity department.

Salute to Alloy Steel Group Includes API Head

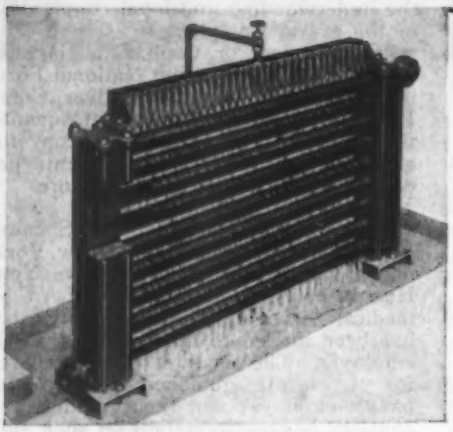
William R. Boyd, Jr., president, American Petroleum Institute, together with seven presidents of other national associations in the Alloy Steel consuming and producing fields, and the presidents of the three largest steel producing companies, have accepted appointments from the American Society for Metals to serve with the society's president, Francis B. Foley, and vice president, Harold K. Work, on the honorary committee covering the "Salute to Alloy Steel," central theme of the National Metal Congress and Exposition.

The society and several affiliated groups will hold their sessions in Philadelphia during the last week in October. ASM convention headquarters will be in the Benjamin Franklin Hotel.

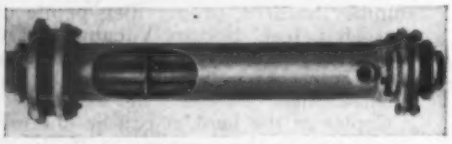
Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

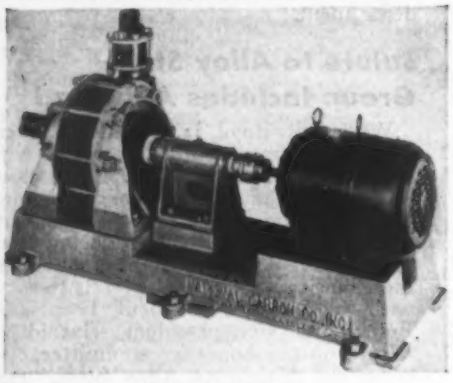
2-Methyl-3,4-pentanedione
3,6-Octanedione
4-Phenylisocrotonic acid
1,4-Diaminonaphthalene
2,5-Diaminotoluene
3-Methyl-2-thiazole aldehyde
Mercaptopyruvic acid
Mercaptosuccinic acid
cis Decahydro-1-naphthol
1,3-Nonadiene
1,3-Heptadiene
2-Hydroxycaprylic acid
S-Benzylthiouronium chloride
1-Vinylcyclohexene-1
Vinylcyclohexane
Vinylcyclopentane
2-Amino oxazole
Cyclooctatetraene
p-Amino-β-hydroxyethylaniline
1,2-Difluoro-1,2-dichloroethylene



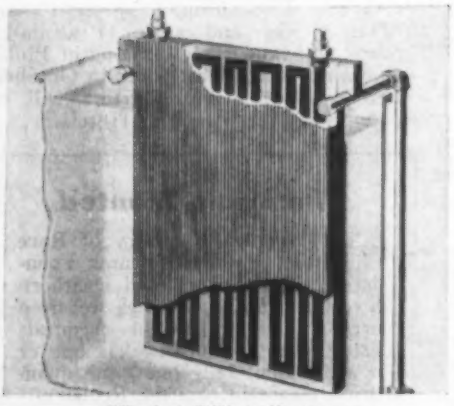
"Karbate" Sectional Cascade Cooler



"Karbate" Series 70 Heat Exchanger



"Karbate" Pump



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FOR HEATING, cooling, pumping, and conveying the corrosive solutions used in pickling and plating metal, there's no better equipment than that made of "Karbate" brand Impervious Graphite. This material is chemically inert, immune to thermal shock, easy to machine and install, light in weight yet strong; and has a very high heat-transfer rate.

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For more details on metal-cleaning systems of standard "Karbate" brand Impervious Graphite units and "National" carbon brick, write to National Carbon Company, Inc., Dept. PR.

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DIGEST of Recent United States PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

AND COVERING PATENTS PUBLISHED IN THE OFFICIAL GAZETTE MAY 11, 18, 25 AND JUNE 1, 8, 1948

Note—Patents digested in the July issue were from Gazettes dated April 13, 20 and 27 and May 4, 1948.

REFINING

U.S.P. 2,441,172. Modified Fuels and Lubricants. S. Shappirio.

The patent concerns a liquid petroleum distillate, such as a hydrocarbon motor fuel or lubricant, containing a metallized amino azo dye. Pb, Sb, Sn, As, Hg and Tl can be employed for the metallization of the dye. The additives serve as anti-oxidants, anti-knock components, anti-gum agents, and the like.

U.S.P. 2,441,400. Acetylene Removal Process. T. F. Doumani and D. A. Skinner to Union Oil Company of California.

Acetylenes, e. g. substituted alpha acetylenes, are separated from a hydrocarbon mixture containing acetylenes and diolefins by contacting this mixture with an aqueous absorption solution having a pH greater than 7 and containing morpholine or tetraethylene pentamine in a concentration greater than about 1 M, a salt of such nitrogen base other than the cyanide in a concentration not greater than 1 M, and a metal hydroxide in a concentration not greater than 0.5 M. A reaction product of the metal and the acetylenes is precipitated thereby without the diolefins being substantially affected. The acetylenes can be recovered from the precipitate by adding it slowly to a boiling azeotropic solution of HCl in water and vaporizing the acetylenes as formed.

U.S.P. 2,441,572. Cyclic Process for Separating Aromatic Hydrocarbons from a Mixture of Hydrocarbons. A. E. Hirschler and M. R. Lipkin to Sun Oil Company.

A mixture of hydrocarbons containing aromatics and boiling mainly above 500° F. is treated with silica gel to adsorb aromatics. The adsorbent is then washed with an organic primary liquid desorbent which has an adsorbability such that, from binary solution of the aromatics and the desorbent, the latter will be preferentially adsorbed by the adsorbent over a major portion of the concentration range. The desorbent is further characterized by an "adsorption index" not greater than 40. The aromatics thus are displaced from the adsorbent. The latter is then washed with a second desorbent comprising a saturated hydrocarbon liquid adapted to effect desorption of the primary desorbent and to reactivate the adsorbent for re-use. Benzene or ethylene dichloride can, for example, be employed as the primary desorbent, and a relatively low boiling saturated hydrocarbon material as the secondary desorbent.

U.S.P. 2,441,827. Extraction Process. A. McKinnis to Union Oil Company of California.

A complex hydrocarbon fraction is extracted with a sufficient quantity of a dicyanoether solvent to dissolve chemically similar components, e. g. relatively unsaturated hydrocarbons, while other chemically similar components different from the first named, e. g. relatively saturated hydrocarbons, are left undissolved. The method can also be used for separating aromatic and non-aromatic hydrocarbons boiling in the same temperature range. The dicyanoether used as the solvent can be a reaction product between acrylonitrile and an alcohol, particularly a polyhydroxy alcohol. Dicyanodiethylsulfide can also be employed as the extracting solvent.

U.S.P. 2,442,011. Production of Solvents. H. R. Legatski to Phillips Petroleum Company.

A feed stream of branched chain paraffin hydrocarbons, as for example obtained by alkylation of olefins with low-boiling isoparaffins, is introduced into a plate type fractionating column. This column is operated under total reflux during the introduction of the feed stream. Introduction of feed is discontinued when flooding of the column plates is imminent. The operation of the column is continued under total reflux until equilibrium between liquid on the various plates of the column and vapors in contact therewith is attained. Substantially odorless fractions of desired boiling range are withdrawn from selected portions of the column. These fractions can be utilized as solvents.

U.S.P. 2,442,073-077. Process for Breaking Petroleum Emulsions. M. De Groote and A. F. Wirtel to Petrolite Corporation, Ltd.

According to U. S. P. 2,442,073 a petroleum emulsion of the water-in-oil type is subjected to the action of an acidic partial ester which contains at least one polyhydric alcohol radical, at least one diglycolic acid radical, and a plurality of acyloxy radicals with 8-32 C atoms, each, derived from a detergent-forming monocarboxylic acid. Examples of such emulsion breaking compounds are triricinolein mono-,di-, and tri-diglycollate.

In the case of U. S. P. 2,442,074 at least one of the polyhydric alcohol radicals of the emulsion breaking compound shall be ester-linked with a group containing the acyloxy radical.

In the case of U.S.P. 2,442,075 a hydroxylated basic tertiary amine, such as triethanolamine, is employed in the production of the emulsion breaking compound.

According to U.S.P. 2,442,076 an esterification product of a compound as used in U.S.P. 2,442,073 with a basic hydroxylated tertiary amine is employed for the same purpose, e. g. the esterification product of triricinolein mono-,di-, or tri-diglycollate and triethanolamine.

U.S.P. 2,442,077 makes use of a compound obtained by esterification between diglycollic acid and a basic acylated aminoalcohol.

U.S.P. 2,442,191. Synthetic Adsorbent for Separating Hydrocarbons. J. F. Black to Standard Oil Development Company.

The solid adsorptive material according to this patent has the empirical formula based on the oxides $4CaO.Al_2O_3.4SiO_2$. It is prepared by reacting a hydrous oxide of Al, a hydrous oxide of Si and Ca $(OH)_2$ for 48-216 hours at a temperature of 100-500° C., cooling the product and dehydrating it. This material is particularly suitable for the adsorption of straight chain hydrocarbons.

U.S.P. 2,442,440. Manufacture of Gasoline. L. P. Scoville to The Texas Company.

This patent relates to the details of a method for the stabilization of a raw cracked naphtha and the manufacture of gasoline hydrocarbons of high anti-knock value from the overhead of the stabilizing operation.

U.S.P. 2,442,474. Purification and Recovery of Furfural in Extractive Distillation of Hydrocarbons. V. Scarth to Phillips Petroleum Company.

The patent relates to a process for the recovery of unsaturated hydrocarbon from its admixture with more saturated hydrocarbon by extractive distillation with furfural containing dissolved water, as selective solvent. Small amounts of water and furfural are volatilized and passed overhead from absorbing and stripping steps. The total overhead from each of these steps is condensed and separated into a hydrocarbon layer and a water layer containing dissolved furfural and corrosive impurities. From the water layers an overhead product consisting of a minimum boiling azeotrope of furfural and water is distilled off. The kettle product which comprises the greater portion of water and the corrosive impurities, is discarded. The furfural rich condensation product is returned to the extraction. The process can, for example, be employed in the separation of butene-1 or butadiene-1, 3 from more saturated hydrocarbons.

U.S.P. 2,442,820. Treatment of Hydrocarbon Oils. D. M. McCormick to The Atlantic Refining Company.

In the extraction of viscous hydrocarbon oil with nitrobenzene, a small amount of an oil-soluble alkaline earth metal sulfonate is added, e. g. 0.01-0.1 percent of calcium sulfonate. The additive prevents emulsification difficulties

and promotes separation of the raffinate from the extract phase.

U.S.P. 2,443,029. Fuel Composition. F. Elkan.

The fuel composition according to this patent consists of 0-15 percent of very high inflammable liquid hydrocarbons of a flash point not higher than 150° F., 0-20 percent readily inflammable liquid hydrocarbons of a flash point of 150-260° F., a substantial amount (up to 20 percent) of paraffin of a flash point of 260-300° F., 0-20 percent heavy hydrocarbon oil of a flash point of 300-600° F., 1-30 percent pitch, 1-12 percent starch, 3-65 percent of finely divided coal material, and 3-60 percent charcoal. The calorific value of each of the hydrocarbons shall be sufficient for igniting the hydrocarbon of next higher flash point. The composition can be used as a fire kindler for igniting anthracite and bituminous coal, coke and the like.

U.S.P. Re. 23,005. Separation of Hydrocarbons. M. R. Lipkin to Sun Oil Company.

A mixture of aromatic and non-aromatic hydrocarbons boiling within the gasoline and kerosene range is treated in liquid phase with silica gel to preferentially adsorb aromatic hydrocarbons. The rich adsorbent is washed at ordinary temperature with a non-aromatic hydrocarbon liquid other than that contained in the original mixture, in sufficient amount to desorb the aromatic hydrocarbons and to reactivate the adsorbent. A liquid mixture of desorbing agent and aromatics is withdrawn from the adsorbent which is re-used in its wet state.

Catalyst Preparation, Activation, and Regeneration

U.S.P. 2,441,214. Hydrocarbon Conversion Catalyst. C. L. Thomas and C. F. Gerald to Universal Oil Products Company.

The hydrocarbon conversion catalyst according to this patent is formed by reacting a polymeric di-alkyl siloxane, a salt of Al, Mg, or Zr, and an aqueous solution of a base to form a precipitate which is then dried. The catalyst is particularly useful in the production of hydrocarbons of branched carbon structures.

U.S.P. 2,441,521. Acid Recovery Process. J. H. A. P. Langen van der Valk and J. D. Ruys to Shell Development Company.

A process for recovery and concentration of spent H_2SO_4 used as an alkylation catalyst is described. The spent acid is diluted immediately after withdrawal from the alkylation system to form a dilute aqueous acid phase and a hydrocarbon phase. The acid phase is then concentrated in three stages. In the first stage it is concentrated at a temperature immediately below the foaming point of the dilute acid, in the second stage the concentration is continued at a temperature above this point and at which organic contaminants are decomposed and rendered insoluble in the acid but below the temperature at which appreciable reaction takes place between acid and the contaminants rendered insoluble during this treatment. In the third stage the acid is concentrated at a temperature corresponding approximately to the b.p. of H_2SO_4 at the desired final concentration.

U.S.P. 2,442,131. Dehydrogenation Catalysts. K. K. Kearby to Standard Oil Development Company.

The catalyst according to this patent consists of 50-97 parts of BeO, 3-50 parts of Fe_2O_3, 3-15 parts of an alkali forming potassium compound e.g. K_2CO_3 or K_2O, and 1-15 parts of CuO or Ag_2O. This catalyst is suitable for the dehydrogenation of mono-olefins and alkylated aromatics having at least 2 C atoms in a side chain.

U.S.P. 2,442,387. Circulation of Oil in Bead Forming Tower. P. D. Valas to Socony-Vacuum Oil Company, Inc.

This patent relates to the production of spheroidal pellets of inorganic oxide hydrogel. A gelable hydrosol of the inorganic oxide is passed downward over a generally conical fluted surface to divide the hydrosol into a plurality of streams, is permitted to fall through a body of water-immiscible liquid and set to a firm hydrogel therein. A stream of this liquid is continuously removed from said body, passed through cleaning means and returned to said body.

U.S.P. 2,442,666. Method of Regenerating HF Catalyst in an Alkylation Process. E. M. Skinner, R. E. Redfield and J. C. Bolinger to Socony-Vacuum Oil Company, Inc.

In the regeneration of HF from hydrocarbon reaction processes employing it as a catalyst, the distillation of the HF is controlled by applying thereto, as a wet reflux, a hydrocarbon substantially inert to the catalyst derived from a point within the hydrocarbon reaction system and beyond the point of main hydrocarbon reaction. Products formed in undesirable side reactions are separated from the catalyst as a distillation residue.

U.S.P. 2,442,772. Preparation and Use of Zirconia Gels in the Conversion of Hydrocarbons. M. M. Marisic and E. M. Griest to Socony-Vacuum Oil Company, Inc.

A water soluble Zr compound and water soluble salts of at least two weak acids are reacted in aqueous solution to effect formation of a homogeneous hydrosol in which zirconia is the major water insoluble inorganic oxide component and which has a pH value of about 4.5. The hydrosol is permitted to set, forming a hydrogel which is washed to remove soluble salts. For example, a solution of $ZrOCl_2.8H_2O$ can be mixed with solutions of ammonium carbonate and ammonium acetate to form the hydrosol. The hydrogel produced is useful as a catalyst in the conversion of hydrocarbons.

U.S.P. 2,442,784. Production of Gels. H. A. Shabaker to Houdry Process Corporation.

The patent describes and claims details of a continuous process for preparing an inorganic gel, e.g., a siliceous gel, from liquid compositions which react to form such gel. The resulting products can be utilized as catalysts in hydrocarbon conversions.

U.S.P. 2,442,884. Manufacture of Spherical Particles. G. M. Webb and R. W. Moehl to Universal Oil Products Company.

Droplets of a sol of a difficultly reducible oxide, e.g., of a silica hydrosol, are introduced to a fluid suspending medium and caused to set therein to hydrogel spheres. These spheres are aged in contact with a dilute acid solution, such as an acetic acid solution, for at least two hours to reduce breakage of the spheres during subsequent drying by heating. The spherical particles obtained are utilized as catalysts in hydrocarbon conversions.

U.S.P. 2,443,056. Catalyst Reactivation. C. Richker to The Texas Company.

The patent relates to the details of a process for the reactivation of a hydrocarbon cracking catalyst susceptible to deterioration by contact with sodium compounds.

U.S.P. 2,443,141. Removal of Metal Halide from Fluids. J. W. Latchum, Jr., to Phillips Petroleum Company.

A vaporous Friedel-Crafts type metal halide is removed from its mixture with organic vapors by contacting this vaporous mixture with pumice impregnated with an alkali or alkaline earth metal hydroxide on which the metal halide is adsorbed. A mixture of the organic vapors and hydrogen halide vapors is recovered.

POLYMERIZATION AND CONVERSION

U.S.P. 2,441,170. Hydrocarbon Conversion by Contact with Active Catalyst and Inert Solid Heat Carrying Material. F. W. Rose and F. W. Steuber to Houdry Process Corporation.

Hydrocarbons are first contacted with a relatively inert fluid solid of controlled heat content to effect direct heat exchange and incompletely vaporize the hydrocarbons. The mixture thus obtained is then mixed at conversion conditions with a fluid solid catalyst continuously passed through a conversion zone. After removal of the converted hydrocarbons from the conversion zone, the fluid solid catalyst is separated from the relatively inert solid by physical means. Examples of such solids are: oxides of the II, III, and IV groups of the periodic table, e.g., corundum, fused quartz, zirconia, sand, and the like.

U.S.P. 2,441,297. Process for Dehydrogenation of Hydrocarbons by Contact with Catalysts Supported on Alumina Stabilized by Aluminum Phosphate. R. I. Stirton to Union Oil Company of California.

Hydrocarbons are subjected to a temperature of 400-1300° F. under a gage pressure of —14 to 1000 psi. in the presence of a catalyst consisting essentially of a major proportion of a stabilized carrier and a minor proportion of a catalytic agent distended thereon. The carrier consists essentially of activated alumina stabilized by the addition of 1-15 percent of aluminum phosphate, while the catalytic agent is a metal oxide or a combination of metal oxides, such as

Cr_2O_3 or cobalt molybdate. The process serves for the conversion, e.g., aromatization, dehydrogenation, or desulfurization of hydrocarbons.

U.S.P. 2,441,311. Method and Apparatus for Contacting Gases and Particle Form Solid Material. J. A. Crowley, Jr., and C. V. Hornberg to Socony-Vacuum Oil Company, Inc.

In a process wherein a particle form solid material and a gaseous reactant are passed to and contacted in a reaction zone and the entrained solid is then separated from the effluent, at least part of the solid material feed stream for the reaction zone is introduced into the stream of separated solid material close to the point where the latter stream leaves the separator. The mixed solid material is passed as a confined compact stream to the reaction zone. The rate of the added solid feed stream at the point of its admixture to the stream of separated solid is maintained sufficiently high to insure continuity all along the length of the mixed stream up to the separator exit.

U.S.P. 2,441,335. Method and Apparatus for Contacting Gases and Solids. E. L. Sinclair to Socony-Vacuum Oil Company, Inc.

The patent claims details of a method and apparatus for contacting a gaseous medium with a contact mass composed of a collected bed of solid particles by passing the gas at velocities not disruptive of this bed.

U.S.P. 2,441,724. Method and Apparatus for Operations with a Contact Mass. T. P. Simpson to Socony-Vacuum Oil Company, Inc.

This patent describes and claims the details of a process and apparatus for introducing particle form contact mass material to a convertor against a gaseous pressure therein.

U.S.P. 2,441,820. Method and Apparatus for Supplying a Slurry. J. W. Jewell to The M. W. Kellogg Company.

The patent relates to details of a method and apparatus for supplying a slurry of a liquid and a finely divided solid, particularly of finely divided solid catalyst in hydrocarbon oil, to a point of use, e.g., to a hydrocarbon reaction zone. A quantity of the slurry substantially greater than that to be supplied to the point of use is circulated.

U.S.P. 2,442,643. Process of Activating Polymerization of Hydrocarbons. W. E. Elwell and R. L. Meier to California Research Corporation.

Normal mono-olefins, such as propylene, are polymerized either alone or with other olefins, such as styrene, butadiene, or the like, in the presence of BF_3 as the catalyst and an accelerator which comprises SO_2 in an amount of 0.1-1 percent by volume of the monomers.

U.S.P. 2,442,644. Method of Controlling Viscosity of Hydrocarbon Polymers. W. E. Elwell and R. L. Meier to California Research Corporation.

The process of this patent is similar to that of U.S.P. 2,442,643. SO_2 is here employed to control the viscosity of the polymer. Amounts of 1-50 percent SO_2 by volume of the monomers are used in this case.

U.S.P. 2,442,645. Polymerization of Unsaturated Hydrocarbons. W. E. Elwell and R. L. Meier to California Research Corporation.

A solution of a mono-olefin with not more than 10 C atoms (e.g., propylene or butylene) in liquid SO_2, e.g., $AlCl_3$ or BF_3. A polymer phase is formed thereby which is insoluble in SO_2. This phase is separated from that of the coordination compound. Polymer is recovered from the SO_2-insoluble phase.

Hydrogenation, Dehydrogenation, Aromatization

U.S.P. 2,441,663. Process for Purifying Saturated Hydrocarbons Involving Selective Demethylation. V. Haensel and V. N. Ipatieff to Universal Oil Products Company.

A hydrocarbon mixture comprising 2,2-dimethylpentane, 2,4-dimethylpentane, and either triptane or cyclohexane, is reacted with hydrogen in the presence of a hydrogenating catalyst, such as a metal of the Fe-group, at a temperature of 150-350° C. At least a substantial portion of the dimethylpentanes is thereby converted into lower boiling hydrocarbons which are separated by fractionation. The concentration of the triptane or cyclohexane in the remaining mixture is thus considerably increased.

U.S.P. 2,442,319. Process and Catalyst for the Dehydrogenation of Olefins. E. C. Britton and A. J. Dietzler to Dow Chemical Company.

An olefin with at least 4 C atoms, such as n-butylene, is passed together with steam at a temperature of 600-750° C. through a bed of catalyst composed for the most part of a normal metal phosphate consisting essentially of phosphate radicals chemically combined with Ca and Ni in the relative proportions of 7.5-9.2 atoms of Ca per atom of Ni. This phosphate can be prepared by mixing a solution of soluble Ca and Ni salts with a solution of a soluble orthophosphate and precipitating the desired normal metal phosphate from the mixture while maintaining the latter in a non-acidic condition. Diolefins, particularly conjugated ones, such as butadiene, are obtained.

U.S.P. 2,442,320. Process for Dehydrogenation of Monoolefins to Diolefins Catalyzed by Calcium Nickel Phosphate-Chromium Oxide Composite. E. C. Britton and A. J. Dietzler to Dow Chemical Co.

The process of this patent is similar to that of U.S.P. 2,442,319. In the present case the normal metal phosphate can contain 7.5-12 atoms of Ca per atom of Ni, and it is combined with a lesser amount of Cr_2O_3. The reaction temperature shall be less than 150° C. above the minimum of the dehydrogenation temperature or below that at which 5 percent of the hydrocarbon material undergoes carbonization.

U.S.P. 2,443,016. Catalytic Process. G. M. Whitman to E. I. du Pont de Nemours & Company.

A mononuclear aromatic hydrocarbon, such as benzene or an alkylated benzene, is hydrogenated to the corresponding saturated cycloaliphatic hydrocarbon, e. g., cyclohexane, by contacting hydrogen with the feed hydrocarbon in the presence of a catalytic amount of metallic sodium at a temperature in excess of 50° C. (e.g., at 150-400° C.) under a hydrogen pressure of 100-15,000 psi.

U.S.P. 2,443,079. Synthetic Drying Oil. F. P. Otto to Socony-Vacuum Oil Company, Inc.

Aromatic hydrocarbon material which largely consists of dimethyl and trimethyl naphthalenes is subjected to exhaustive catalytic hydrogenation. The product obtained which largely consists of alkyl decalins is halogenated at a temperature of 20-80° C. for a period of time sufficient to yield a product which contains 25-35 percent by weight of halogen. This product is dehydrogenated in the presence of a suitable catalyst, such as CaO, for a period of time sufficient to reduce the halogen content of the product to less than 4 percent by weight. The resulting product has the properties of a drying oil.

CRACKING AND REFORMING

U.S.P. 2,441,142. Cracking Hydrocarbons in the Presence of Bromine-Containing Terpenic Compounds. H. O. Folkins to The Pure Oil Company.

Hydrocarbons are subjected to suitable cracking conditions in the presence of a small amount of bromine-containing terpenes, camphors, their ester or ethers or amino, nitro, alkyl, aryl, or aralkyl derivatives. A temperature of 650-1200° F. can, for example, be used for producing hydrocarbons in the gasoline boiling range from higher boiling hydrocarbon oils in the presence of 0.05-3 percent by weight of a bromo-camphor.

U.S.P. 2,441,240. Process for Hydrocarbon Conversion in the Presence of Added Terpenes plus Nonmetallic Bromine Compounds. H. O. Folkins to The Pure Oil Company.

The process of this patent resembles that of U.S.P. 2,441,142. In the present case a mixture of Br_2, HBr, a phosphorus bromide, or a metal- and metalloid-free organic bromine compound with a small amount of a halogen-free terpene or terpene derivative is employed for sensitizing the reaction.

U.S.P. 2,441,666. Powdered Catalyst Process. F. B. Johnson to Standard Oil Development Company.

Hydrocarbon oil to be cracked is vaporized at a temperature substantially below that of final cracking and at a rate to avoid any substantial cracking. A finely divided catalyst is then injected into the oil vapors. The initial temperature of the catalyst shall be materially above the final cracking temperature. The relative proportion of catalyst and oil vapors and the initial temperature of the catalyst are adjusted to rapidly increase the temperature of the oil vapors to the final cracking temperature. The suspension of catalyst and oil vapors is kept within the cracking zone for a period sufficient to obtain the desired conversion of the oil. A motor fuel is obtained by fractionation of the cracking products after separation of the catalyst.

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U.S.P. 2,441,962. Production of Long-Chain Olefins by Catalytic Cracking of Paraffinic Wax. W. I. Gilbert and C. W. Montgomery to Gulf Research & Development Company.

Paraffinic wax is subjected to cracking conditions in the presence of a catalyst comprising a hydrated magnesium silicate-calcium silicate compound at a temperature of 815-900° F. A liquid space velocity of 0.5-2 is employed. Olefin hydrocarbons of 12-20 C atoms are produced.

U.S.P. 2,441,974. Method of Catalytic Cracking. W. A. Pardee and C. W. Montgomery to Gulf Research & Development Company.

This is similar to U.S.P. 2,441,962. The same catalyst is employed here for producing a gasoline with high olefin content from hydrocarbon oil at a temperature of 925-1000°F. and at a space velocity of 3-6.

U.S.P. 2,442,060. Production of Aromatic Hydrocarbons of High Purity. R. M. Shepardson to Standard Oil Development Company.

Heavy naphthas containing paraffins are heated to about 1400° F. for a period of time of about 0.5-1.0 second to completely destroy those paraffins in the naphtha which boil in the range of the desired aromatic fraction and form aromatic compounds and olefins and diolefins. The cracked products are fractionated to separate an aromatic fraction in the desired boiling range free of paraffins and of normally gaseous olefins. This fraction is treated with conc. H_2SO_4 to remove olefins and diolefins and can be purified further by distillation. Benzene of over 99 percent purity and nitration grade toluene can be obtained by the process.

U.S.P. 2,442,276. Conversion of Hydrocarbons. T. W. Nelson, H. D. Noll, and T. B. Simpson to Socony-Vacuum Company, Inc.

This patent describes and claims details of a process for the production of aviation gasoline by cracking a gas oil in vapor phase in the presence of an adsorptive catalyst and subjecting a naphtha segregated from the reaction products and being of the general nature of motor gasoline to a second cracking operation under more rigorous conditions. The heavy naphtha segregated from the reaction products of this second cracking which comprises material boiling above the range of aviation gasoline but does not contain material boiling substantially above 488° F. is subjected to a third cracking under still more rigorous conditions. A gasoline of aviation fuel end point is obtained from the effluent of the third cracking zone.

ISOMERIZATION

U.S.P. 2,442,418. Isomerization of Normal Paraffin Hydrocarbons by Contact with Aluminum Chloride Supported on a Metal Halide. J. W. Latchum, Jr., A. D. Pickett, and G. B. Evans to Phillips Petroleum Company.

Normal paraffin in admixture with HCl as a promoter is passed under isomerization conditions over a catalyst consisting of $AlCl_3$ supported as a thin layer on the surface of a carrier. This carrier consists of a granular chloride of a metal

of the left-hand column of Group I of the periodic system, e.g., NaCl. The $AlCl_3$ shall constitute 1-40 percent by weight of the granular chloride. The $AlCl_3$ shall be supported as such on the surface of the granular chloride without mingling of the two materials. The cheap and easily available carrier employed gives excellent results.

HEAVY OILS AND WAXES

U.S.P. 2,441,202. Purified Plasticized Wax and Process of Preparing the Same. C. E. Maier and J. D. Green to Continental Can Company, Inc.

The patent relates to an odor and flavor free microcrystalline petroleum wax composition which is particularly suitable for lining metal beer containers. The composition is a blend of about 84 percent by weight of such a wax composition having an ASTM melting point of about 160° F. and an ASTM penetrometer value of about 9-11 with 16 percent of a pharmaceutical grade of white petrolatum having an ASTM m.p. of 115-120° F. The wax composition shall have no acid number and saponification value and have an NPA color greater than 1.

U.S.P. 2,441,331. Mineral Oil Composition. O. M. Reiff and H. J. Andress, Jr., to Socony-Vacuum Oil Company, Inc.

A viscous mineral oil fraction is mixed with a minor proportion of an oil-soluble, acidic, phosphorus-, sulfur- and nitrogen-containing reaction product obtained by reacting a phosphorus sulfide and a phosphorus amine of an alkyl substituted hydroxyaromatic compound, such as diamyl phenol. This additive lowers the pour point of the mineral oil, raises the viscosity index and substantially inhibits corrosion of metal parts.

U.S.P. 2,441,496. Lubricating Oils. B. H. Lincoln, G. D. Byrkit, and W. L. Steiner to Continental Oil Company.

The composition according to this patent comprises a major proportion of an oil of lubricating viscosity, a minor proportion of sulfurized monomeric olefin, and a minor proportion of an organic phosphorus compound. The olefin of the sulfurized compound is obtained from a narrow-cut petroleum fraction, or by halogenating and dehydrohalogenating petroleum wax. The corrosion and oxidation inhibiting properties of the lubricant are improved by addition of the sulfurized olefin. The phosphorus compound increases the detergency and peptizing character of the lubricant.

U.S.P. 2,441,587. Method of Preparing Composition of Matter Suitable for Use as a Lubricant and as an Addition Agent to Lubricants. J. M. Musselman to Standard Oil Company of (Ohio).

Phosphorus sulfide is reacted at a temperature of at least 270° F. with an organic oxygen-containing compound of a b.p. higher than this reaction temperature. An oil-soluble product is formed. At least part of a phosphorus and oxygen-containing by-product formed is neutralized by the addition of an alkaline reacting compound. A further amount of phosphorus sulfide is then brought to reaction with the reaction

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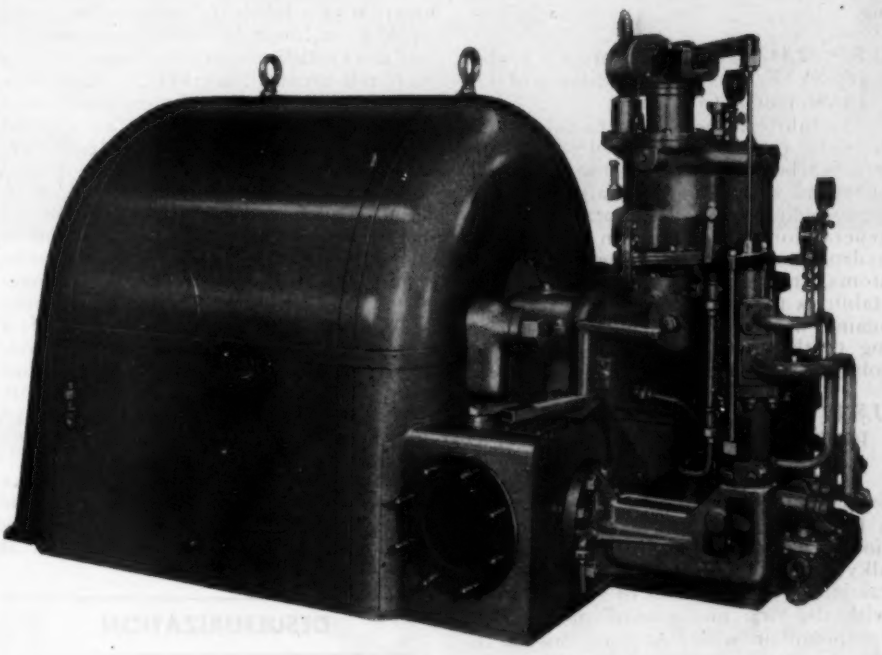

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mixture obtained. The separated reaction product is used as a lubricant or an additive for mineral oils to improve their lubricating properties.

U.S.P. 2,441,720. Lubricant. T. G. Roehner and G. W. Murray to Socony-Vacuum Oil Company, Inc.

The lubricating grease composition according to this patent comprises the reaction products of 30-50 percent of fatty material, 4½-7½ percent of alkali, 40-60 percent of mineral oil, and ½-10 percent of a water-dispersible cellulose ether. The composition is characterized by resistance to deformation and "bleeding."

U.S.P. 2,442,134. Lubricant. E. Lieber and A. F. Cashman to Standard Oil Development Company.

The lubricant according to this patent consists of a halogenated petroleum hydrocarbon which contains active halogen and sulfur, and a small amount of monocyclic aromatic hydrocarbon of the general formula $C_6H_4R_2$ in which R is hydrogen or an alkyl group with 1-5 C atoms, such as p-cymene. The additive stabilizes the extreme pressure lubricant against degradation during storage leading to the formation of ingredients insoluble in paraffinic mineral oils.

U.S.P. 2,442,581. Rust-Preventing Composition. J. W. Bishop to Tide Water Associated Oil Company.

The composition comprises a major proportion of a liquid hydrocarbon (e.g. a lubricating oil) and a minor proportion of a salt formed by an oil-soluble alkyl acid ester of phosphoric acid containing an alkyl group of 8-18 C atoms with the ring nitrogen of an oxazoline compound in which at least one of the ring C atoms carries a long chain alkyl group. The additive which is dissolved in the hydrocarbon, inhibits rusting of metal surfaces.

U.S.P. 2,442,672. Rust-Preventive Hydrocarbon Compositions. G. H. v. Fuchs and N. B. Wilson to Shell Development Company.

The composition comprises a mineral lubricating oil or refined diesel oil fraction, .001-.1 percent of a stable saturated polycarboxylic acid with at least 16 C atoms, and .001-1 percent of an alkyl phenol oxidation inhibitor. The composition is rust-preventive and can, for example, be used as a turbine oil.

U.S.P. 2,443,026. Stabilized Grease Compositions. J. G. Detwiler to The Texas Company.

The grease composition according to this patent comprises a homogeneous mixture of a mineral oil, e.g. a lubricating oil, sufficient metallic soap, such as lime soap, to thicken the oil to a gel, and 0.05-5.0 percent by weight of tetra methyl diamino diphenyl methane. The latter additive works as a texture stabilizing agent.

U.S.P. 2,442,915. Mineral Oil Composition. H. G. Berger and E. W. Fuller to Socony-Vacuum Oil Company, Inc.

The composition according to this patent comprises a viscous mineral oil fraction, a minor amount of 0.5-10 percent of an oil-soluble metal sulfonate or metal carboxylate, and 0.5-5 percent of an oil-soluble P and S containing reaction product obtained by reaction of 1 mol of P_2S_5 and 4 mols of oleyl alcohol at a temperature of 125-150° C. The reaction time-reaction temperature relationship shall be so maintained that the acidity (N. N.) of the reaction product is not greater than 25. The sulfonate or carboxylate works as a detergent, while the other additive greatly improves the corrosion and oxidation characteristics of the composition.

U.S.P. 2,443,082, 2,443,083. Synthetic Lubricant. O. M. Reiff, H. D. Hartough, and H. J. Andress, Jr. to Socony-Vacuum Oil Company, Inc.

Both these patents relate to the production of a lubricant with a pour point of 0° F. or lower by partial halogenation of a crystalline paraffin wax with a m.p. not greater than 140° F. A mixture of halogenated wax and non-halogenated wax is obtained containing an amount of halogen corresponding to 18-25 percent chlorine. This mixture is mixed according to U. S. patent 2,443,082 with toluene and according to the second patent with xylene in the proportion of at least one mole of the hydrocarbon to each atom of halogen in the halogenated wax mixture. The resulting mixture is heated in the presence of a Friedel-Crafts type condensation catalyst until all of the halogenated wax has reacted with the aromatic hydrocarbon. After removal of the catalyst, unreacted hydrocarbon and non-halogenated wax a small amount of an ester of an alkyl-substituted phenol, such as tetra-wax phenol phthalate, is added to the residue in sufficient quantity to characterize the lubricant obtained with a pour point at least as low as 0° F.

DESULFURIZATION

U.S.P. 2,441,493. Desulfurization of Hydrocarbons with Boron Phosphate-Alumina Catalyst. R. C. Krug to The Atlantic Refining Company.

Hydrocarbons which contain S compounds are contacted with a boron phosphate-alumina catalyst at a temperature of 600-800° F. for a period of time sufficient to convert the S compounds to H_2S, which is removed. Desulfurized hydrocarbons are recovered. No substantial decomposition of hydrocarbons occurs during the treatment. The catalyst can, for example, be composed of 5-25 percent BPO_4 and 95-75 percent Al_2O_3.

U.S.P. 2,442,982. Desulfurization of Hydrocarbons. F. C. Nachod to The Atlantic Refining Company.

Hydrocarbons which contain sulfur compounds are contacted with lead alumino-silicate at a temperature of 400-900° F. Desulfurization is effected.

PETROCHEMICALS

U.S.P. 2,441,258. Purification of Sulphonic Salts. J. C. Carter to Tide Water Associated Oil Company.

A metal mahogany sulfonate which contains occluded oil as an impurity from its production by petroleum oil with H_2SO_4 is treated to remove the occluded oil. For this purpose one part of the sulfonate to be treated is mixed with more than one part of a water-immiscible selective solvent, viz. a nitroparaffin, such as nitropropane, to dissolve the oil. The undissolved metal sulfonate is separated. The treating temperature shall be in excess of the point of complete mutual solubility of the oil and solvent, e. g. above 150° F.

U.S.P. 2,441,287. Process for the Production of Ethylene Dichloride. A. S. Ramage to A. A. F. Maxwell.

Ethylene is reacted with Cl_2 in the presence of a catalyst comprising essentially amorphous Pb, Ag, and Sb.

U.S.P. 2,441,515. Interpolymers of a Styrene, an Allylic Acrylate, and an Allylic Alcohol. R. H. Snyder to United States Rubber Company.

The patent relates to ternary interpolymerizates of a styrene, an allylic acrylate and an allylic alcohol wherein the proportion by weight of the latter is at least 10 percent of the total weight of the other reactive monomers. A peroxide catalyst can be used in the production of these interpolymers.

U.S.P. 2,441,945. Copolymer Compositions Containing Finely Divided Metal Particles. P. K. Frolich and I. E. Lightbown to Jasco, Inc.

The composition according to this patent comprises in combination a synthetic, solid, plastic hydrocarbon interpolymer of a major proportion of isobutylene with a minor proportion of a diolefin having 4-6 C atoms. The composition is characterized by a low unsaturation expressed by an iodine number below 40, a mol. wt. above 15,000 and reactivity with S to yield a product of increased elasticity together with copper powder. The cured interpolymer has an elastic limit and a tensile strength at break above 1,000 psi.

U.S.P. 2,442,068. Sulfur-Chloride Treated Butyl Rubber as Tie-Gum. R. F. Wolf and W. J. Sparks to Standard Oil Development Company.

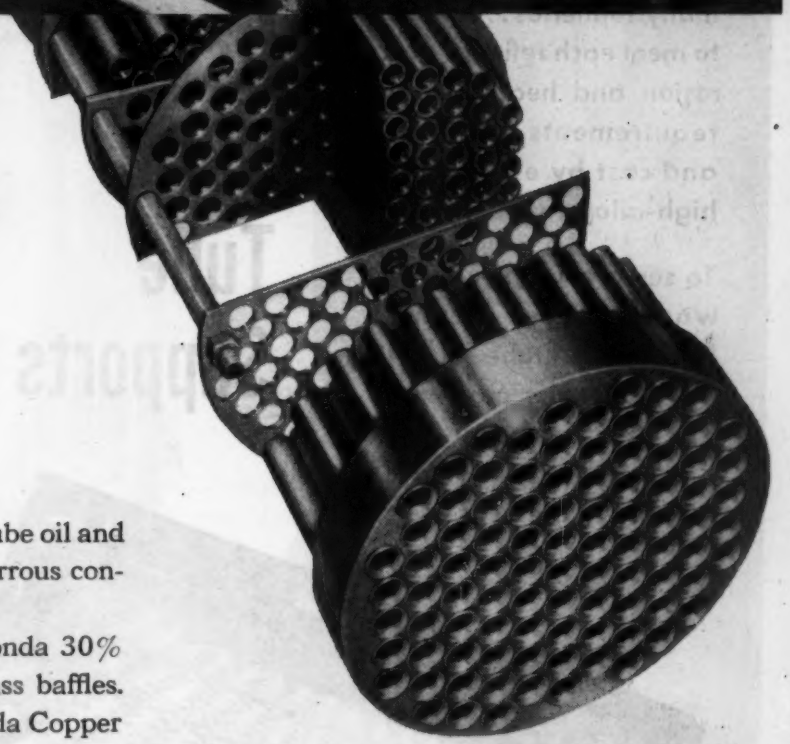
This patent concerns a flexible, elastic structure which comprises in combination a body of cured natural rubber, a body of cured elastic hydrocarbon interpolymer of a major proportion of isobutylene with a minor proportion of a polyolefin with 4-12 C atoms, such as isoprene, butadiene, or dimethyl butadiene, and an interposed tie-gum layer comprising a polymer of a major proportion of isobutylene with a minor proportion of a polyolefin with 4-12 C atoms and containing SCl_2 in chemical combination. The elastic limit and tensile strength of the produced structure at break is above 1000 psi.

U.S.P. 2,442,089. Plasticizers. E. Lieber to Standard Oil Development Company.

A kerosine is chlorinated until it has a 16 percent Cl_2 content. The chlorokerosine obtained is refluxed with phenol in the presence of a condensation catalyst, such as $ZnCl_2$. The resulting product mixture is cooled, washed with aqueous HCl and then distilled. A fraction boiling between 450-650° F. is recovered and subsequently esterified with an organic carboxylic acid. The final product can be utilized as a plasticizer.

U.S.P. 2,442,218. Interpolymers of Isoolefine with Diolefins and Process of Producing Same. W. J. Sparks and R. M. Thomas to Jasco, Inc.

An interpolymer obtained at a low temperature from a major proportion of



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isobutylene and a minor proportion of a conjugated diolefin, such as butadiene, and which has a mol. wt. of 15,000-150,000 and an iodine number of 1-45, is treated with a sulfur chloride. HCl is withdrawn from the treated polymer which is milled to incorporate, if desired, such substances as carbon black, ZnO, stearic acid, S and a sulfurization agent. A plastic, elastic rubbery material is obtained.

U.S.P. 2,442 283. Emulsion Copolymerization of Vinylfurane and Styrene. W. Bock to General Aniline & Film Corporation.

Styrene and vinylfurane are copolymerized in an aqueous emulsion in the presence of oxygen or oxygen-yielding substances as polymerization accelerators. The amount of styrene shall not exceed 50 percent of the polymerizable material used. The products obtained are only slightly colored and can be used as lacquer raw materials and in the manufacture of moulded articles.

U.S.P. 2,442,323. Process of Making Perchlorethylene. C. W. Davis, P. H. Dirstine, and W. E. Brown to Dow Chemical Company.

A gaseous mixture of CH_4, Cl_2 and CCl_4 in which the molar ratio of Cl_2 to CH_4 is 2-6 and the molar ratio of CCl_4 to CH_4 is 0.5-5, is passed in the absence of a chlorination catalyst into an insulated reaction zone. The amount of CCl_4 vapors is chosen within the indicated limits so that the reaction temperature controlled by dilution and heat absorption is maintained above 500° C. but below the decomposition point of CH_4. Perchlorethylene is separated from the reaction mixture.

U.S.P. 2,442,324. Process of Making Carbon Tetrachloride and Perchlorethylene. R. G. Heitz and W. E. Brown to Dow Chemical Company.

This process is related to that of U.S.P. 2,442,323. Aliphatic hydrocarbons with 1-3 C atoms and their partially chlorinated derivatives are subjected to total chlorination. The diluent added to the gaseous mixture of the starting material and Cl_2 can be CCl_4, perchlorethylene, or mixtures of both. The amount of Cl_2 present in the mixture shall be in excess of that required for complete chlorination. The amount of diluent shall be such that the temperature during the reaction is maintained at 500-700° C. without external heating or cooling.

U.S.P. 2,442,558. Plasticized Copolymers of Compounds Containing a Single $CH_2{=}C<$ Group and Diesters of Ethylene Alpha Beta Dicarboxylic Acids. G. F. D'Alelio to Pro-phy-lactic Brush Company.

The patent contains reference to a composition which comprises a copolymer of styrene or another vinyl compound with a maleic acid ester, and a plastizer for this copolymer obtained from cyclopentadiene and a maleic acid ester.

U.S.P. 2,443,044. Copolymerization Process. W. H. Lycan and H. L. Gerhart to Pittsburgh Plate Glass Company.

Cyclopentadiene or its low polymers up to the pentamer are mixed with an unsaturated glyceride oil, e.g. linseed oil or soya bean oil, in a closed system at a temperature of 450-600° F. This tem-

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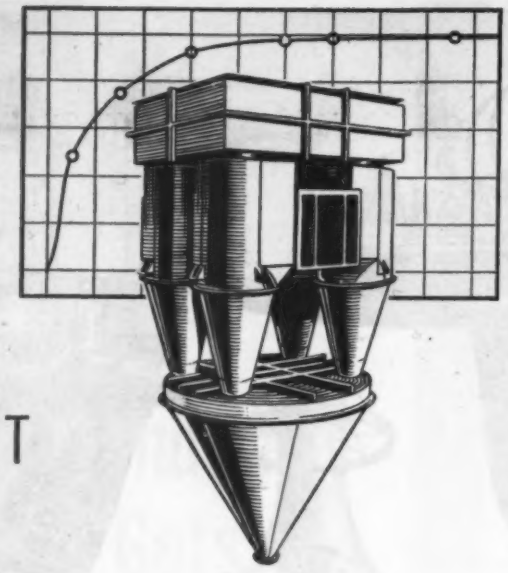

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perature is maintained until the pressure of the reaction mixture drops substantially to zero and a product is formed which is soluble in petroleum naphtha.

ALKYLATION

U.S.P. 2,441,249. Catalytic Alkylation Process for the Manufacture of High Anti-knock Gasoline. C. L. Ocon and E. A. Ocon.

High anti-knock gasoline is continuously produced by subjecting normally gaseous hydrocarbons under pressure in a liquid phase, comprised chiefly of isoparaffins and olefins (e.g., of isobutane, n-butane, and butenes), to the action of strong H_2SO_4 catalyst and BF_3 in the presence of a controlled liquid propane concentration restricted to 1-10 percent by volume of the hydrocarbons present in the reaction zone.

U.S.P. 2,442,160. Two-Stage Alkylation with Olefin Streams Containing Propylene and Ethylene. C. O. Baker to Socony-Vacuum Oil Company, Inc.

This patent relates to the details of a process for the recovery and utilization of propylene and ethylene contained in a gaseous stream of light hydrocarbons by production of high octane motor fuel by alkylation of isoparaffins with the propylene and ethylene.

U.S.P. 2,442,221. Alkylation-Recycling of Alkylate Product Stream Free of Inert Gases. A. R. Sydnor, Jr., to Standard Oil Development Company.

This invention relates to details of a process for the alkylation of an isoparaffin with a C_2 or C_3 olefin admixed with inert gas including H_2 in the presence of a liquid catalyst, such as an $AlCl_3$-hydrocarbon complex, at elevated temperature and under sufficient pressure to maintain the isoparaffin, e.g., isobutane, in the liquid phase.

U.S.P. 2,442,342. Process of Making Isopropyl Benzene. R. E. Burk and E. C. Hughes to Standard Oil Company (Ohio).

Cumene is continuously produced by the process of this patent from a refinery gas containing propylene and a stoichiometric excess of a technical grade of benzene with appreciable amounts of impurities of higher or lower b.p., in the presence of HF promoted by BF_3 under alkylating conditions. Details of the process are claimed.

National Guard Leaves

Continental Oil Company employes, members of the National Guard or organized reserves, will be granted leaves of absence up to 15 days for annual military service. Officials also announced Continental will supplement the reservists' government pay during the period with an amount sufficient to bring their earnings up to their regularly scheduled wage or salary level.

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The school of chemical engineering at the University of Oklahoma, Norman, has been expanding its graduate program during the past few years and is now authorized to offer a Ph.D. degree. A few graduate assistantships and industrial fellowships are available.

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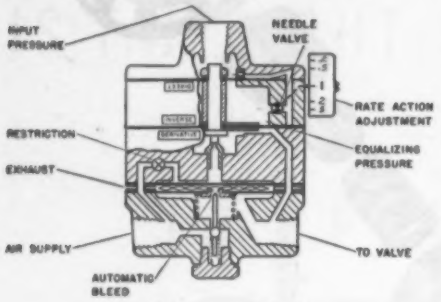
59—Inverse Derivative Unit



INVERSE DERIVATIVE UNIT

An "inverse derivative unit" for use with Moore Products' Nullmatic controller has been developed, the purpose being to superimpose, on the output of the controller, an entirely new type of control action. Like the controller, this unit operates on the pneumatic force-balance system. It is designed for application on all processes in which the reaction time through the process is faster than the correction time through the control valve. In a fast-acting process, a direct derivative control function will generally serve to amplify the tendency to cycle, becaue the control valve cannot be made to move as fast as the process. With inverse derivative action, narrower proportional band settings are possible. The instant the process tends to become unstable, or to go into a cycle, the inverse derivative unit acts to temporarily widen the proportional band, which action restores stability to the process.

For further information write Moore Products Company, H and Lycoming Streets, Philadelphia 24, referring to PETROLEUM REFINER item 59.

60—Templates

Timely Products Company is offering a set of engineering flowplan templates designed to render "Draftsman Quality" symbols with a minimum of effort. These "Flowplanner" templates, an engineered instrument set for the petroleum and organic chemical industries, permit uniform symbols in sizes suitable for flowplans and field work. Templates are made of transparent plastic and are 6⅞ by 4⅜ by .025 inches in size.

For further information write Timely Products Company, Box 206, Columbus 9, Ohio, referring to PETROLEUM REFINER item 60.

61—Test Gage

Helicoid has announced a standard test gage for use with Reid vapor test bombs. It may also be used for any service where an accurate, portable test gage is required. Accuracy of the new Reid vapor test gage is guaranteed to within ½ of 1 percent. It has the stainless Helicoid precision movement. Dial size is 4½ inches and made of white laminated phenol. The flangeless case in acaloy and is weatherproof with an external micrometer pointer adjuster.

For further information write Helicoid Gage Division, American Chain & Cable Company, Inc., Bridgeport, Conn., referring to PETROLEUM REFINER item 61.

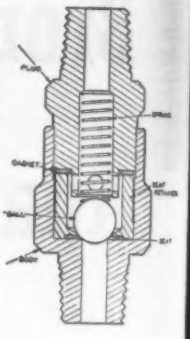
62—Diaphragm Control Valve

Hammel-Dahl Company has announced its 4000 series Flo-Tested pressure loaded diaphragm control valves, which eliminate both packing boxes and springs. These valves provide "supersensitive regulation wherever the controlled fluid may come in direct contact with the diaphragm." Fluid pressure from the outlet side of the body is applied to the under side of the larger area diaphragm instead of springs. Loading pressure from a remote operator or air operated instrument is applied to the upper side of the diaphragm in the usual way. While either cast iron or steel bodies can be provided, the steel diaphragm cases are so large in area that the maximum working pressure of this valve is 250 psi. When firing boilers or stills on natural gas, these valves prevent inlet pressure variations from disturbing the controlled gas pressure. These valves may be thought of as a large relay. The normal ratio of input to output pressure is 1 to 1. Any range from 8 to 1 or 1 to 8 may be provided for special applications. The 4000 Series valves use large area diaphragm cases made from 3/16-inch steel stampings.

For additional information write Hammel-Dahl Company, 243 Richmond Street, Providence 3, R. I., referring to PETROLEUM REFINER item 62.

62A—Check Valve

Improving the seat in their check valves by the addition of a soft non-extruding plastic valve seat results in these Hoke, Inc., valves "being able to withstand high back pressures without danger of seat damage." These new plastic seats do not tend to fly to pieces under back pressures in excess of 1000 pounds. In spite of "this capacity to withstand high pressures, these valves seat off and open at very low pressure differentials." They are precision made of brass, with other metals on special order.



For additional information write Hoke, Inc., of Englewood, N. J., referring to PETROLEUM REFINER item 62A.

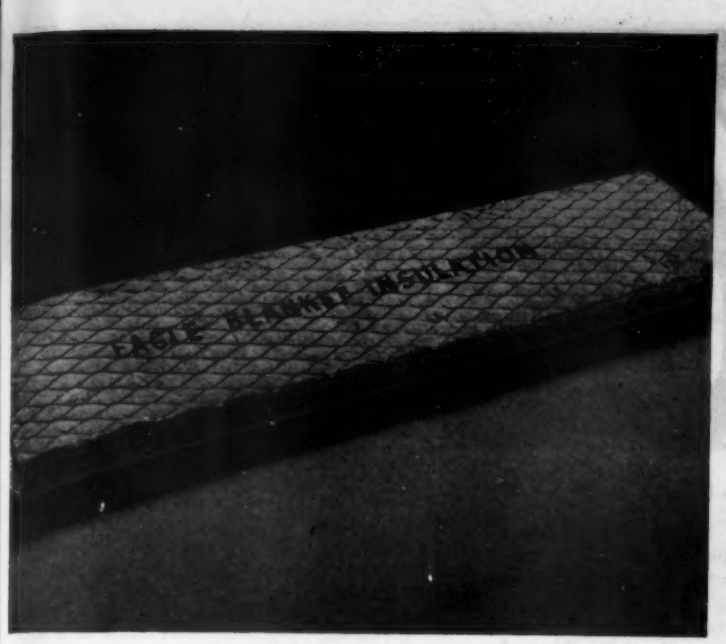
63—Tube Cleaners

Greatly increased power is claimed by Elliott Company for its new Rotojet junior cleaners for small tubes. The equipment is designed to remove scale and other deposits from tubes as small as .495-inch I.D. in boilers, condensers, etc. These tube cleaners are said to develop unusual power, considering their small size and weight. They are fed easily through the tubes with the operating hose. Rotojet motors are available for operation with air or water. The air-driven motors have only two moving parts, a shaft and a paddle. An egg-shaped bore cylinder maintains positive contact with the paddle, and assures an undivided air stream and freedom from leakage. An air valve behind the motor gives the operator instant control of air. The water-driven motors offer a radical design improvement in the turbine wheel and other parts.

For Bulletin J-410 or further information write Elliott Company, Roto Division, Newark 1, N. J., referring to PETROLEUM REFINER item 63.

64—Hard-Facing Method

Engineers of wall Colmonoy Corporation, claim a revolutionary advancement in hard-facing methods for their recent development, "Spraweld Wire." This new metallizing wire consists of a hard facing alloy and a binder. The two are mixed and extruded into coils of wire ⅛ and 3/16-inch. In use as the wire goes through the flame of the metallizing gun the binder burns away and particles of Colmonoy No. 6, the hard facing alloys are deposited on the surface being sprayed. Colmonoy No. 6, the hard-fac-



Temperature control demands
EAGLE-PICHER
Insulations

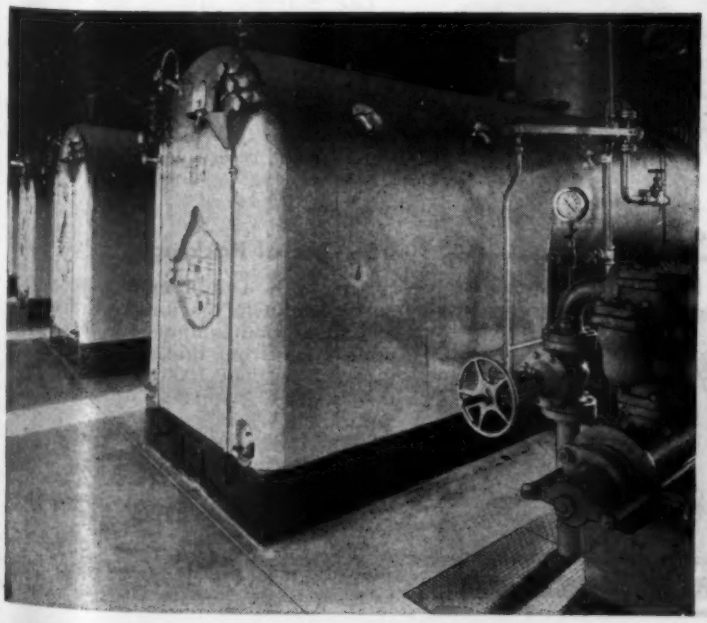
Eagle-Picher Mineral Wool Blankets

are physically and chemically stable!

Long service on heated equipment does not lower the high insulating efficiency of Eagle-Picher Blankets. Their principal ingredient, Eagle-Picher Mineral Wool, does not break down or deteriorate despite continuous exposure to temperatures as high as 1200 F. Outstanding physical and chemical stability enables Eagle-Picher Blankets to permanently resist water, steam, corrosive fumes and normal vibration. Complete technical and application data sent on request.

Let these Eagle-Picher products also save you money...power...time

Insulating Felts
Supertemp Block • Blankets
Loose Wool • Pipe Covering
Stalastic • Insulseal • Insulstic
Swetchek • Finishing Cements
Insulating Cements



EAGLE-PICHER INSULATIONS for *High and low temperature*

EAGLE EP PICHER

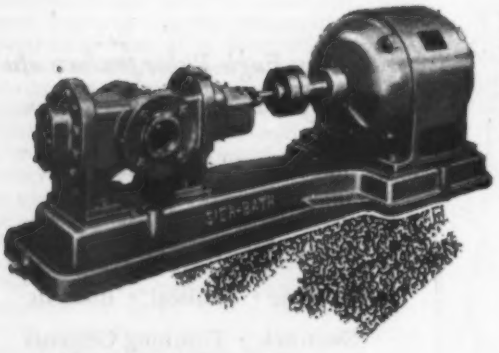
Since 1843
THE EAGLE-PICHER COMPANY
CINCINNATI (1), OHIO

Can a pump be TOO GOOD?

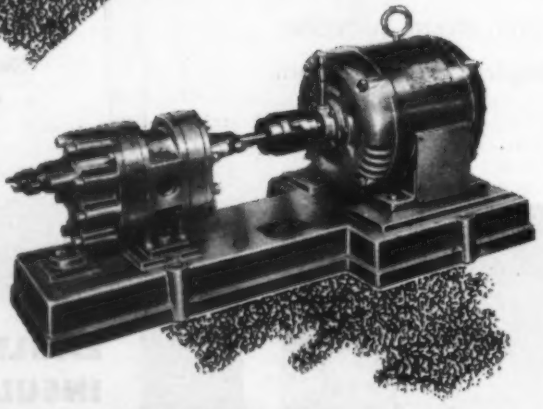
WE believe that no pump used in industrial processes can be too good. The cost of only one shut-down for pump replacement or repair often exceeds the difference in price between the best pump it is possible to obtain—and the second-best.

That is why we put *everything* that engineering ingenuity can devise into Sier-Bath Screw Pumps and Gearex Pumps. As a result, Sier-Bath Pumps are noted for their dependability and durability and for requiring the absolute minimum in down-time for maintenance.

Sier-Bath Screw Pumps and Gearex Pumps are made in a modern plant under the best working conditions, by a company that has long been noted for the manufacture of precision gears. In the making of our pumps we adhere to the rigid standards of high quality that have made Sier-Bath Precision Gears famous among manufacturers of quality products. Send for booklet on Sier-Bath Screw Pumps or Sier-Bath Gearex Pumps.



SIER-BATH Screw Pump Advantages: Pulseless flow, anti-friction bearings, vibrationless operation, low maintenance costs, rugged construction. Pumps acetate, asphalt, brines, bunker C fuel oil, cellulosics, greases, molasses, syrups, lube oil, etc.



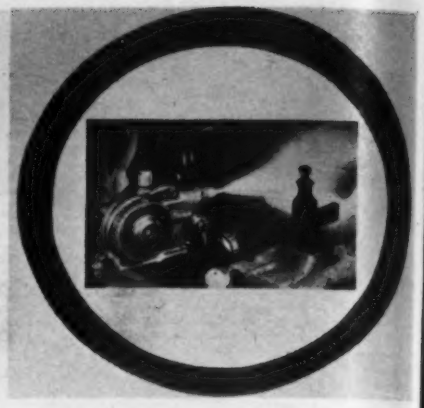
SIER-BATH Gearex Pump Advantages: balanced axial thrust, vibrationless operation, roller bushings for precision running under load. Pumps oils, varnishes, solvents, molasses, chemical solutions. Capacities 1-550 g.p.m. Discharge 250 p.s.i. for medium or high viscosities, 50 p.s.i. for water.

ALSO MAKERS OF SIER-BATH PRECISION GEARS

FOUNDED 1905 MEMBER A. G. M. A.

Sier-Bath GEAR and PUMP CO., Inc.

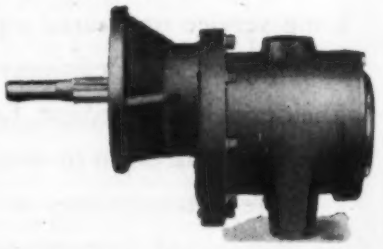
9249 HUDSON BOULEVARD • NORTH BERGEN, NEW JERSEY



ing alloy, is said to be more corrosive-resistant than stainless steel and claims to outwear steel from 3 to 40 times, to be non-galling, non-magnetic and non-sparking. The Colmonoy "Sprayweld" process consists of a combination of metallizing and welding procedures, using metallizing methods to apply smooth uniform Colmonoy overlays and welding methods to bond these overlays to the base metal, and is not to be confused with conventional metallizing.

For further information write Wall Colmonoy Corporation, 19345 John R. Street, Detroit 3, referring to PETROLEUM REFINER item 64.

65—Air Starting Motor



Ingersoll-Rand Company is producing air motors of two sizes as starters for internal combustion engines. The air motor is keyed or splined to the Bendix or starting mechanism and the engine is cranked in the same manner as an automobile engine is turned over when using the electric starter.

The Starting Motors are known as the Size 9BM and Size 20BM; the former having 9 horsepower and the latter 20 horsepower at 90 psi air pressure. They are small and compact.

For additional information write Ingersoll-Rand Company, 11 Broadway, New York 4, referring to PETROLEUM REFINER item 65.

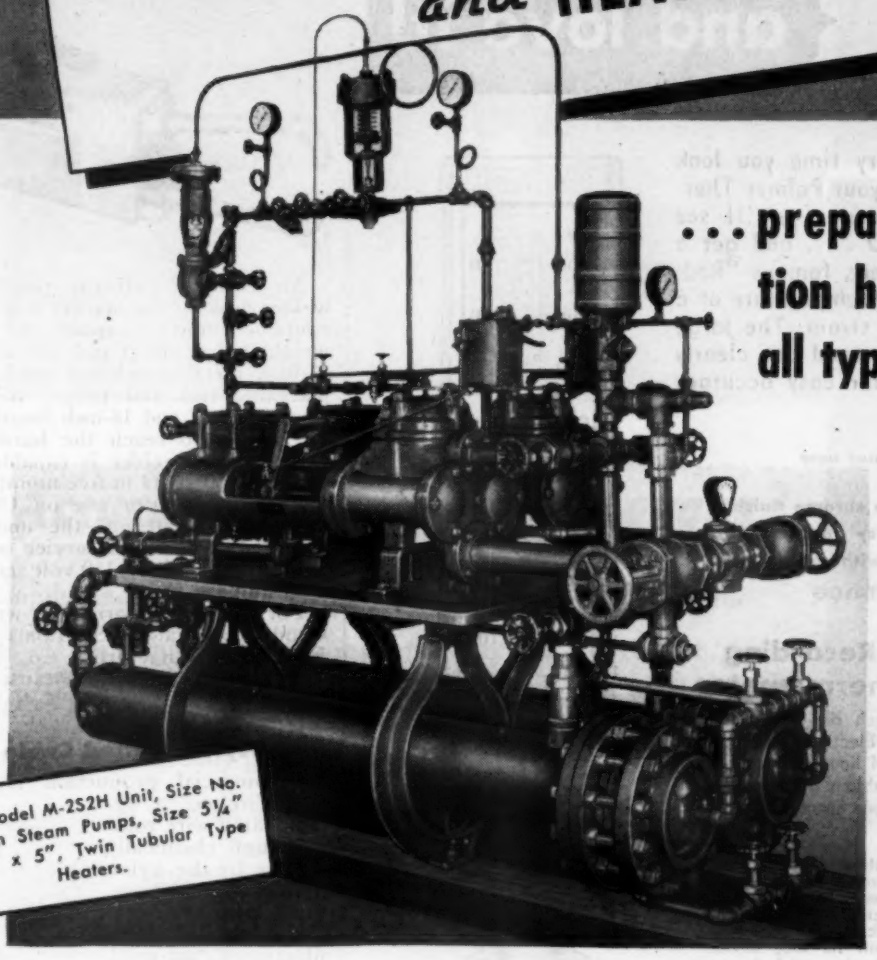
66—Metal Packing

Scientific Development Company's pertruded metal packing for distillation and absorption columns consists of small units made from thin metal which contains more than 1000 holes per square inch and is shaped into half cylinders with the corners or edges bent inward to prevent stacking. The holes are not clean cut but a pertrusion or burr is formed on one side. These burrs and holes permit the metal to be readily wetted by liquids.

The packing is installed by simply pouring into the column. No supports are necessary for at least 15 feet in

NATIONAL AIROIL FUEL OIL - GAS BURNERS

FUEL OIL PUMPING *and* HEATING UNITS



P-857 Model M-2S2H Unit, Size No. 15, Twin Steam Pumps, Size 5¼" x 3½" x 5", Twin Tubular Type Heaters.

...prepare for combustion heavy fuel oil for all types of oil burners

National Airoil Fuel Oil Pumping and Heating Units are especially designed to prepare, for combustion, what is commonly termed No. 6 or Bunker C Fuel Oil. They will draw fuel oil from above ground or underground tanks, preheat it to proper constant temperatures and deliver it to Oil Burners at an even pressure, best suited for the burners. Our Fuel Oil Pumping and Heating Units are the result of years of experience. They come completely equipped ready for steam, exhaust, condensate, oil suction, oil return, and where motor driven pumps are used, electrical connections. All valves, regulators, etc., are readily accessible. The piping arrangement is easily understood. These compact, space-saving units are available in a range of sizes and models in both Medium and High Pressure types. For complete details, write for our Bulletin 40—very interesting and informative.

NATIONAL AIROIL BURNER CO., INC.

Main Offices & Factory: **1254 EAST SEDGLEY AVENUE, PHILADELPHIA 34, PA.**

Texas Office: 2nd National Bank Bldg., Houston

INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

You'll see RED

and love it!

Every time you look at your Palmer Thermometer you'll see RED . . . and get a quick, accurate reading. Palmer's famous "Red-Reading-Mercury" tells you the temperature at a glance with no squint . . . no strain. The large black numerals and markings stand out clearly on the white-enameled scale for easy accuracy of reading that *you'll love!*

Get all the Palmer advantages in your new thermometer . . .

- **New extruded brass case with chrome finish**
- **Guaranteed permanent accuracy and sensitivity**
- **Dougle-strength glass shield with snap-on cap**

WRITE FOR NEW CATALOG

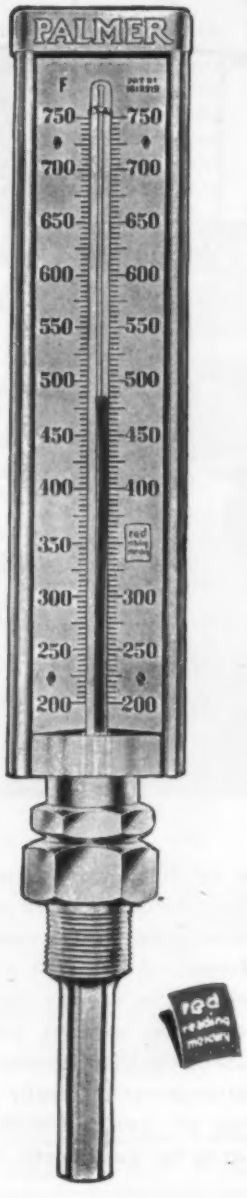
Recording Thermometer

12 inch die-cast aluminum case. Electric or spring clock 12, 24 hour or 7 day charts available in all ranges. Fountain pen standard.

Palmer "Superior" Recording and Dial Thermometers are Mercury Actuated. Extremely accurate and sensitive. Built for long service. Atomic welded construction. Flexible armoured tubing and bulb of stainless steel. All parts rust-proof. Ranges up to 1000 F. or 550 C.

Dial Thermometer

6 inch and 8 inch round case. Standard dials available for all ranges. Equipped with micrometer adjusted hand.



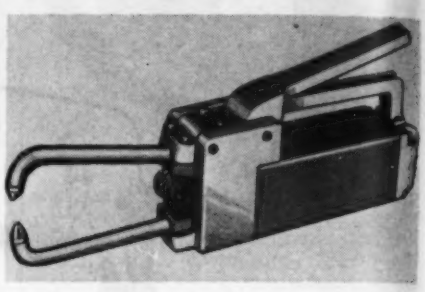
PALMER THERMOMETERS INC.

Mfrs. of Industrial, Laboratory, Recording and Dial Thermometers
2513 NORWOOD AVE., CINCINNATI 12, OHIO
Canadian Plant:
KING AND GEORGE STS., TORONTO 2

height. Packing density is 44 pounds per cubic foot with 92 percent free space. Pieces are approximately 0.16 by 0.16 inches with 1,200,000 pieces per cubic foot.

For additional information write Scientific Development Company, Box 795, State College, Pa., referring to PETROLEUM REFINER item 66.

67—Portable Spot Welder



An entirely different portable spot welder now on the market is a new self-contained unit, compact and light in weight (23 pounds) and will weld up to ⅛-inch metal, combined thickness. Replaceable tips and tongs, available in stock in 6, 12 and 18-inch lengths, enable the welder to reach the hard-to-get-at corners. The welder is capable of spot welding 150 spots in five minutes. There are six models for use on 110-volt or 220-volt a.c. current—the unit can be operated on 220-volt service with a 15-ampere fuse and on 110 volt service with a 30 ampere fuse.

For complete information write Metal Goods Corporation, St. Louis or Miller Electric Manufacturing Co., Appleton, Wis., referring to PETROLEUM REFINER item 67.

68—Nylon-Coated Cable

Commercial production has started of "Wirelon," a nylon-coated wire rope.

Although chemically similar to the nylon used in women's hose, the coating on Wirelon is not woven or filamented, but solid. It is very tough. Wirelon is available in diameters ranging from 1/32-inch to 1-inch or greater. The du Pont nylon coating is unaffected by oils, cleansing agents, marine growths, and all alkalies, is not harmed by such acids as nitric, hydrochloric, or sulphuric in concentrations up to approximately 1 percent. Wirelon ropes operate well at high and low temperatures and the ropes retain their flexibility whether wet or dry.

For additional information write Rochester Ropes, Inc., Culpeper, Va., referring to PETROLEUM REFINER item 68.

69—Shut-Off Valve

A new valve, announced by Sellers Injector Corporation, is intended for service with hot acids, strong or highly corrosive solutions, hydrocarbons, and other penetrative fluids, and it is claimed that such materials can be handled with assurance of tight shut-off despite corrosive action or deposits

How Accurate are Your Tank Gauges?

Depth measurement of crude oil or refined products in storage tanks require accurate readings of at least 1/16 inch. In large tanks, this means accuracies as high as *one hundredth of one percent.* Any gauger knows that this accuracy can only be obtained with an actual tape reading.

"VAREC" Automatic Tank Gaugers permit actual tape readings without the necessity of climbing tanks and opening hatches with loss of volatile products. They are built gastight and more than pay for themselves by vapor savings alone. Available for all types of storage tanks, they can be installed on tanks already in service. Typical installations are illustrated in the "VAREC" P-7 Handbook and Catalog. Special adaptations have been designed for gauging solids. If you have a gauging problem, write to "VAREC" today.

"VAREC" Look box window showing gauging tape, indicator and gravity compensator scale

If the specific gravity of the tank contents is changed—for example, when a tank is changed from 60° gasoline to 40° distillate service, or vice versa—it is not necessary to readjust the entire gauge mechanism to compensate for the difference in buoyancy of the float when using a "VAREC" Gauge. Such a change in service would result in a change in the buoyancy of the float of approximately 3/8 inch, an error of approximately 60 bbls. in an 80,000 bbl. tank. With the "VAREC" Gauge, it is only necessary to move the indicating arrow in the look-box (adjustable from the outside) to a point opposite the prevailing gravity on the compensator scale and the volumetric reading will be accurate for the new prevailing contests. Patent No. 1879805.

P-4

"Varec"

THE VAPOR RECOVERY SYSTEMS COMPANY

COMPTON, CALIFORNIA, U.S.A.

NEW YORK 30 Church Street · CLEVELAND 1501 Euclid Ave. · CHICAGO 122 So. Michigan Ave. · TULSA 533 Mayo Building · HOUSTON 821A M. & M. Bldg.

Cable: VAREC COMPTON (all codes)

From Any Angle ...It's WILLSON For Safety With Comfort

A FLARE FOR PROTECTION . . . Side wings on this metal-edged, easy-to-wear Protecto-Shield* give extra protection . . . deflects splashing liquids from face, head and eyes.

FOR SPLASH-PROOF EYES . . . Rolled, resilient edges of this Over-All* rubber mask goggle hug facial contours to keep out chemical splash and metal spatter. Tops in comfort and protection.

DOUBLE BARRELED PROTECTION . . . Two replaceable chemical cartridge filters highly effective against low concentrations of vapors; provide low breathing resistance. *Reg. U. S. Pat. Off.

For complete information on these products and their application, as well as many more eye and respiratory protective devices, get in touch with your nearest Willson distributor or write us direct.

GOGGLES • RESPIRATORS • GAS MASKS • HELMETS

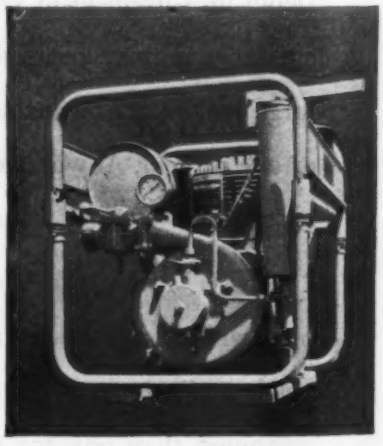
DOUBLE WILLSON PRODUCTS INCORPORATED

READING, PA., U. S. A. Established 1870

on the valve parts. Featured are a self-cleaning action, multiple seat design, and injection sealing for emergency conditions. The valve is available in ½" to 10" sizes with choice of standard flange connections.

For additional information write Sellers Injector Corporation, 1623 Hamilton Street, Philadelphia 30, referring to PETROLEUM REFINER item 69.

70—Fire Pump



A new self-powered centrifugal pumping unit, announced by Hale Fire Pump Company, meets the need for a portable general-purpose unit for numerous applications. Available either with hand carrying frame, a barrow type carriage with pneumatic tires, or for stationary mounting, the Model FZZ is a complete pumping system with capacity: 60 U. S. gallons per minute at 90 pounds pressure and 150 U. S. gpm. at 30 pounds. Typical applications range from use as emergency fire equipment to pumping water from excavations, emptying or filling tanks or tank cars, construction work, and many others.

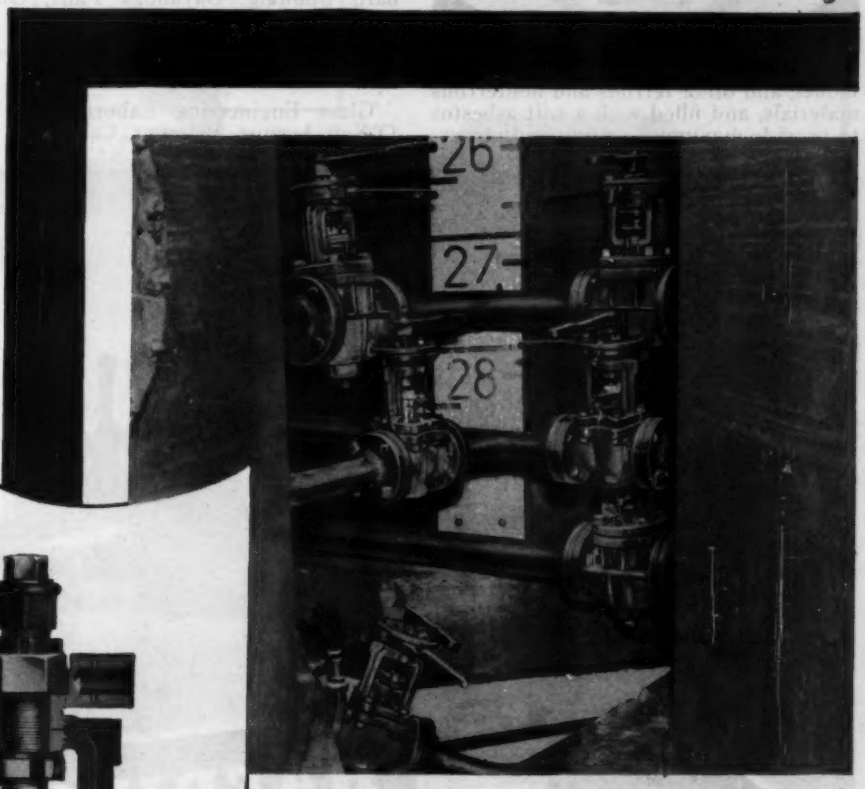
For additional information write Hale Fire Pump Company, Conshohocken, Pa., referring to PETROLEUM REFINER item 70.

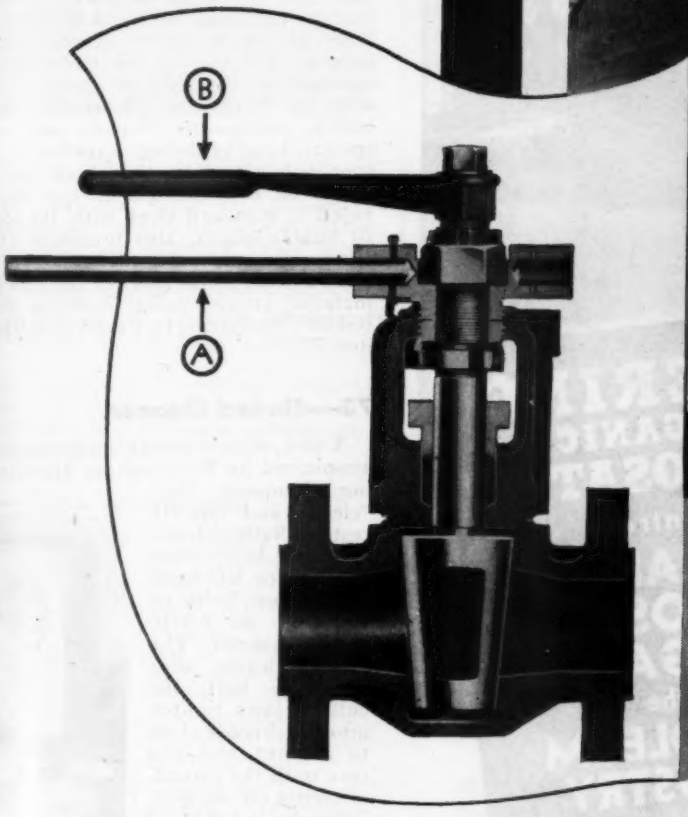
71—Metallic Gaskets

The U. S. Gasket & Shim Company has announced development of a standard line of metallic gaskets fabricated of light gauge brass, copper, lead, nickel,

"Instant, Stick-Proof Operation *at all Times, Under all Conditions*"

with HOMESTEAD Lever-Seald Valves





NOTE THESE OUTSTANDING FEATURES

1. Instant Stick-proof operation.
2. Quarter-turn fully opens or closes.
3. Positive seal without lubrication.
4. Seating surfaces always protected in both open and closed positions. Corrosion practically eliminated.
5. Unobstructed straight-line fluid flow.
6. All operating parts protected from damaging effects of service conditions and weather.

A powerful lever-and-screw device—built into each valve—prevents sticking and assures positive action at all times and under all conditions. Corrosive or viscous fluids, temperatures as low as 40° below Zero or as high as 1120° F., pressure or other adverse conditions that ordinarily cause valve failures, cannot affect the operation of Homestead Lever-Seald Valves.

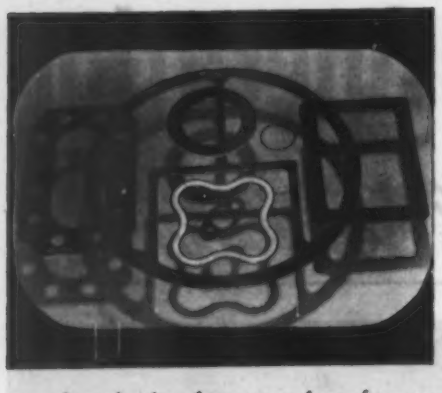
Homestead Lever-Seald Valves operate faster too, 16 to 28 times faster than screw-stem-type valves. Seating pressure is first relieved with the lower lever "A" just enough to overcome friction. Then a quarter-turn of the upper lever "B" fully opens or closes the valve. Full seating pressure is again applied with the lower lever to make a positive, leakless seal.

Homestead Lever-Seald Valves can be furnished in combinations of metals and alloys to suit your requirements in sizes 1¼" to 10", for pressure from vacuum to 1500 pounds.

Write today for full information and copy of Section 3, Valve Reference Book No. 39.

HOMESTEAD VALVE MANUFACTURING CO.

P. O. BOX 16 **CORAOPOLIS, PA.**

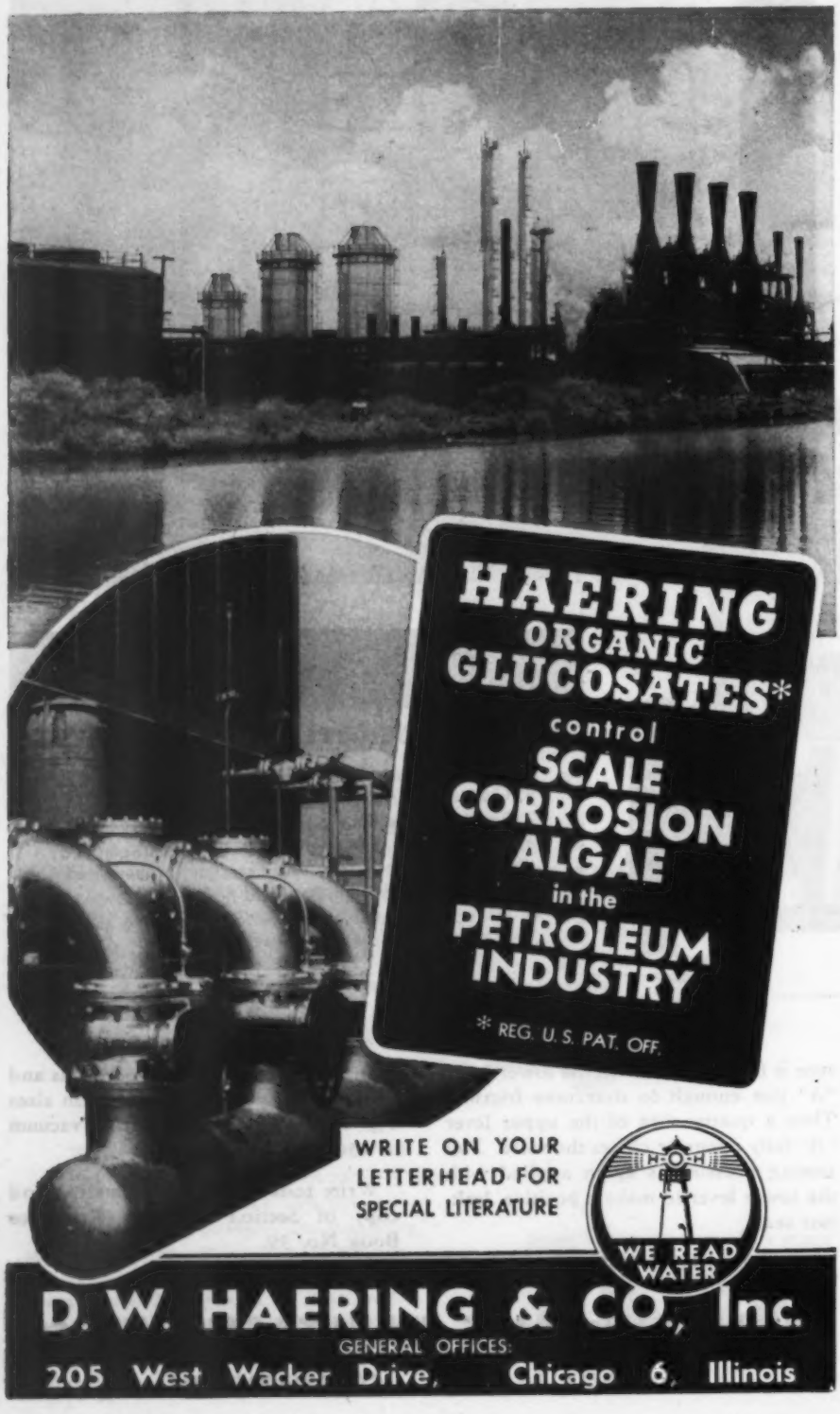


monel, and other ferrous and nonferrous materials, and filled with a soft asbestos to provide maximum sealing and protection against extreme pressure, heat, and corrosion. They will withstand temperatures up to 850° F., and pressures as great as 1500 psi. Seal is effected by the yielding, or flow, of the gasket material into the imperfections of the separable mechanical assemblies. These metallic gaskets can be made in any shape or size and are fabricated to meet any specifications. Location of bolt holes is held to within .015-inch tolerance.

For further information write The U. S. Gasket & Shim Company, 203 Hibbard Building, Cuyahoga Falls, Ohio, referring to PETROLEUM REFINER item 71.

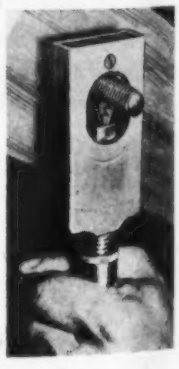
72—Fractionating Columns

Glass Engineering Laboratories, 585 O'Neil Avenue, Belmont, Calif., has announced the extension of its line of laboratory and pilot-plant Oldershaw-type bubble-plate columns to include two new sizes: two-inch and four-inch. The new two-inch size, like the one-inch, has a permanently-evacuated jacket to insulate for low heat loss so external heat is not required unless operating temperature exceeds 450 F. In the two-inch size, sections are supplied in standard form with 10, 15, 20, and 30 precision-drilled bubble plates—the 30-plate and longer special lengths being unjacketed. The four-inch size, like the three-inch, has industrial end fittings. It can be provided in standard sizes with 10, 15, and 20 bubble plates, also precision drilled. Pyrex glass is used throughout on all sizes and no metal touches the processed material at any point. Ask for Folder 2G448FC4 referring to PETROLEUM REFINER item 72.



73—Thread Cleaner

A new, widely versatile thread cleaner, announced by Buckingham Manufacturing Company, Inc., "cleans and quickly restores flattened, distorted or badly rusted right or left-hand threads on bolts or studs up to 2-9/16 inches diameter." The thread cleaner slips over the bolt, the cutting jaws tighten into the threads close to the nut, and you turn until the threader comes off the bolt. Threader is easily set and held to size by a single lock nut on the knurled handle.



For additional information write to Buckingham Manufacturing Co., Inc., Binghampton, N. Y., referring to PETROLEUM REFINER item 73.

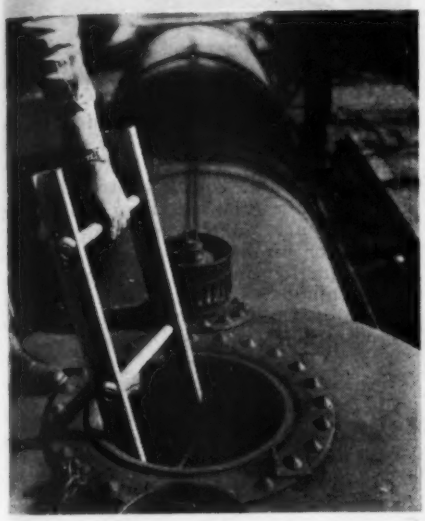
74—Pipe Joint Compound

Crane Packing Company has announced an improved pipe joint compound known as plastic lead seal No. 2 (Underwriters' Laboratories approved). Brushed on threads, gaskets, flanges, etc., it stops galling or rust of threads and never hardens or dries out. It as-

sures tight, permanent joints that are easily taken apart later. The compound does not injure or stain polished finishes, is insoluble, will not wash out and seals air, water, steam, refrigerants, butane, propane, other petroleum derivatives, CO^3, etc., at temperatures to 500° F.

For additional information write Crane Packing Company, 1600 Cuyler Avenue, Chicago 13, referring to PETROLEUM REFINER item 74.

75—Aluminum Ladder



W. E. Brosius Company has announced a new all-aluminum tank car ladder featuring such advantages as lightness, strength, durability, resistance to fire and non sparking. This ladder, riveted throughout and utilizing corrugated rungs, has an outside width of 12 inches and weighs 1 pound per foot. It is available in any length through 16 feet.

For additional information write W. E. Brosius Company, 711 House Building, Pittsburgh 22, referring to PETROLEUM REFINER item 75.

76—Observation Door

Bigelow-Liptak Corporation's observation door consists of a heavy frame arranged for mounting directly against an exterior furnace wall (brick, steel, or asbestos board casing for a suspended wall, or a suspended or solid masonry wall itself.) The shutter or inner door is attached to a shaft rotating within the main frame and operated externally by a lever and pull chain. A plastic ball of low-heat conductivity attached to the lens frame permits lifting the latter and when in its top position, it will remain full open. In the event full and continued opening of the observation door is desired for use as a poke hole, it is then necessary only to lock the shutter in open position by means of its pull chain.

For further information write Bigelow-Liptak Corporation, 2842 West Grand Boulevard, Detroit 2, referring to PETROLEUM REFINER item 76.

77—Flexible Tubing Parts

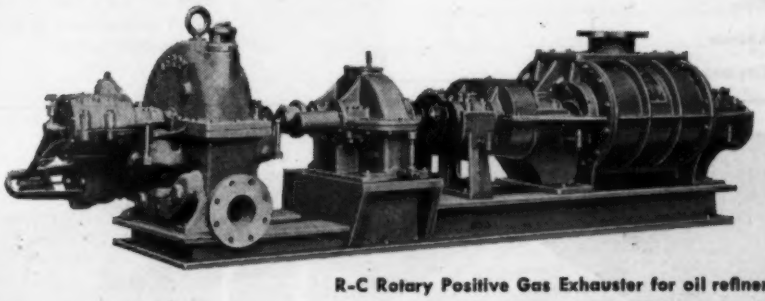
Design development affording interchangeability is announced by Ronaflex. These flexible tubing assemblies, with snap-on couplings, are interchangeable on various nipples. For instance, the ⅜-inch coupling body fits ¼, ⅜, and ½-

Oil was first produced by drilling in 1859, five years after the first Roots Blower was built. We're not good because we're old, but old because we're good.

NO "HEDGING" ON BLOWER QUESTIONS FROM

R-C dual-ability

R-C Multi-stage Centrifugal Gas Exhauster, turbine-driven. Capacity 20,000 CFM.



R-C Rotary Positive Gas Exhauster for oil refinery service. Capacity 750 CFM.

When you ask Roots-Connersville engineers about blowers, exhausters or gas pumps for refinery or petroleum processing applications, you'll get unbiased answers, without "hedging" between Centrifugal or Rotary Positive equipment.

That's because of our *dual-ability* to design and build both types. We recommend whichever is best suited to the specific application. We are the only blower builders offering you this important *dual choice* . . . an advantage which usually saves time, money and trouble.

You'll obtain outstanding performance from R-C equipment, too . . . the result of 94 years of experience plus the advanced thinking of alert engineers and designers.

So, for any problem of moving or measuring gas or air—consult R-C *dual-ability*.

ROOTS-CONNERSVILLE BLOWER CORPORATION
808 Crescent Avenue Connersville, Indiana

ROOTS-CONNERSVILLE
ROTARY CENTRIFUGAL
BLOWER BUILDERS R-C SINCE 1854
BLOWERS · EXHAUSTERS · BOOSTERS · LIQUID AND VACUUM PUMPS · METERS · INERT GAS GENERATORS

★ ★ ONE OF THE DRESSER INDUSTRIES ★ ★

millions of dollars worth

of expert research at your finger tips

in this new book!

ALKYLATION OF ALKANES

Volume I: Patents on Alkylation of Alkanes
by GUSTAV EGLOFF and GEORGE HULLA

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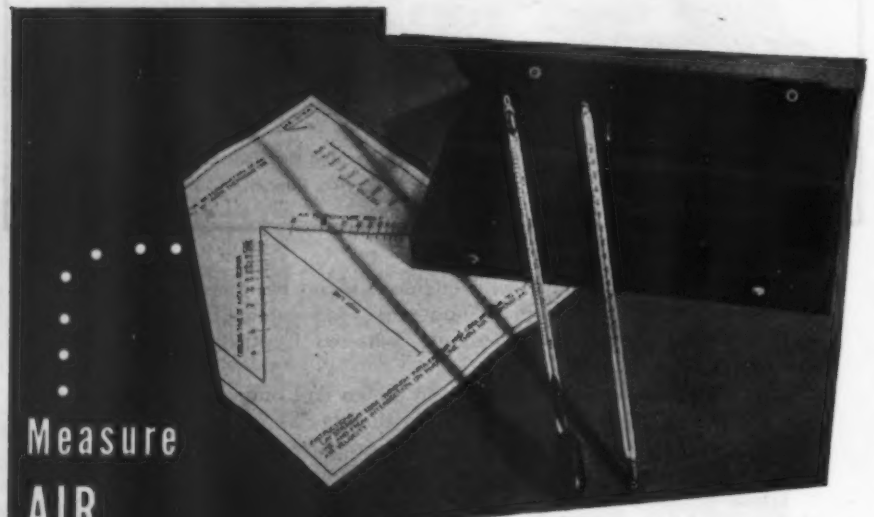

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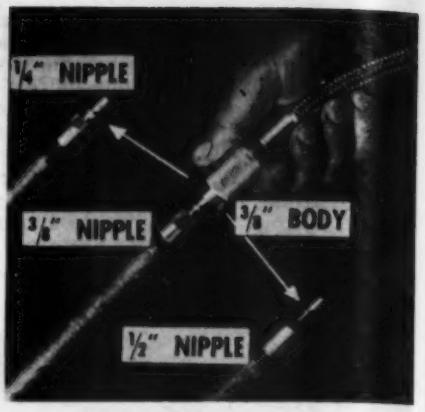

inch nipples. The ¼ and ½-inch bodies also fit all three nipples. The degree of interchangeability varies with the type of coupling and with the size. The 1½ and 2-inch regular coupling bodies, for example, are interchangeable with 1½ and 2-inch nipples.

For further information write Ronaflex Tubing Company, Inc., Packard Building, Philadelphia 2, referring to PETROLEUM REFINER item 77.

78—Self-Powered Telephone

A self-powered telephone, designed for applications where power supply is unavailable or uncertain, and requiring no batteries or other power supply, is now available. The telephone system is said to embody many safety features, inasmuch as both talking and ringing circuits are entirely free of all electric sparks. Too, the units generate no heat. Because of the safety features, it is thought the instrument will find wide use in oil tankers and barges, in gas, explosive, volatile solvent and chemical plants, in oil fields and refineries, etc. The instruments are said to function efficiently both in or out of doors and are claimed to be effective in installations of up to 20 miles. Since no external sources of electrical power are involved, transient noises, such as crackling and frying experienced in conventional battery-power-actuated phones, are eliminated.

For further information write Wheeler Insulated Wire Company, Inc., Waterbury, Conn., referring to PETROLEUM REFINER item 78.

79—Ultracentrifuge

Characterized as a research tool for the centrifugal purification and molecular-weight determination of particles in the larger molecular size range, the Spinco Ultracentrifuge offers a unified design housed in a single enclosure and ready for full operation with the simple connection of power and cooling water. Sound insulation is not required because the unit is powered with a quiet electric drive. Essentially, the machine consists of means for driving various types of rotors at adjustable constant speeds up to 70,000 rpm, together with associated controls and related apparatus for measurement and observation of

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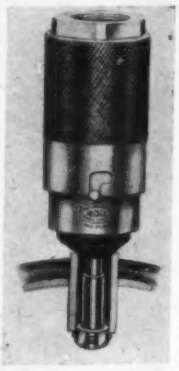
conditions relative to the sample under observation.

For further information write Specialized Instruments Corporation, 1154 O'Neill Avenue, Belmont, Calif., referring to PETROLEUM REFINER item 79.

80—Test Plug and Connector

Mechanical Products Corporation has announced a new line of "Hydro-Matic" self-sealing test plugs and pressure line filling connectors equipped with expanding head pull rods, employing a unique sealing principle and requiring only a couple of seconds to insert or remove. They are designed to seal plain or threaded holes in flanged or fitted openings of practically any depth in tanks, boilers and other fabricated or cast vessels which require hydrostatic or air pressure testing. Featured is the manner in which testing pressure from within the tank or vessel is utilized to actuate a piston or plunger with sufficient force to hold an effective seal regardless of the actual testing pressure used.

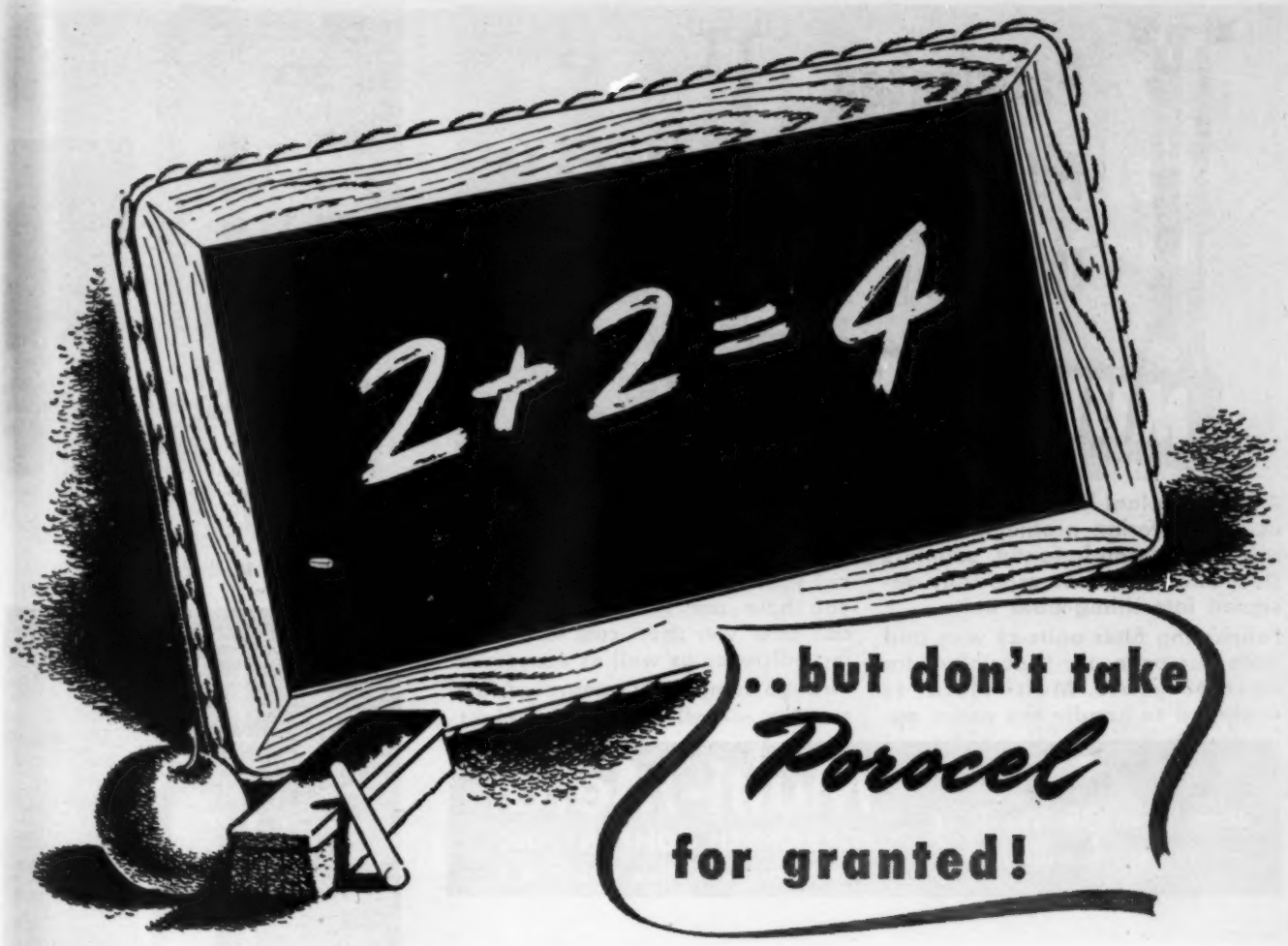


A safety feature and positive holding action is controlled by the bayonet lock-in cylinder.

For additional information write Mechanical Products Corporation, 168 North Ogden Avenue, Chicago 7, referring to PETROLEUM REFINER item 80.

81—Automatic Liquid Balance

The flow measurement of any liquid can now be automatically determined by weight by the use of the new Erdco automatic liquid balance, a device that operates without any interruption of the flow. By eliminating the possibility of human error, it obviates the necessity for time-consuming reruns. Because the operation is entirely automatic, there is nothing to be done or watched after the switch is turned on, and the operator is completely free to perform other duties during the weighing cycle. Other definite advantages claimed: liquid wastage is stopped; there is no carry-over when



Porocel—a "family" of granular activated bauxites—is well known to most refiners. Its profitable uses in the percolation finishing of oils and waxes and as desulfurization and reforming catalyst are legion. But don't take it for granted that Porocel's value is limited to its common uses. It is *un*commonly versatile!

Consider Porocel, for instance, in your expanding Chemical Products plans. It's likely there's a multitude of scrubbing operations where, during the course of making petro-chemicals, other materials introduced must have their last traces removed in order to gain complete stability. These are jobs for Porocel with its large and highly active surface area and its chemical inertness. And Porocel's doing these tasks every day with sulfur, acids, fluorides and other impurities.

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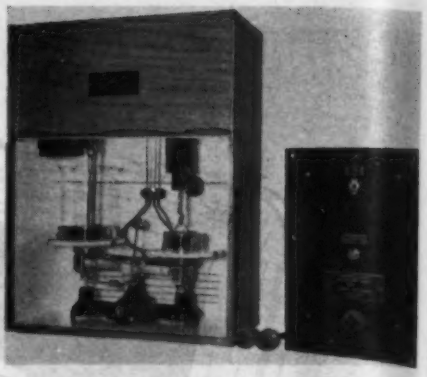
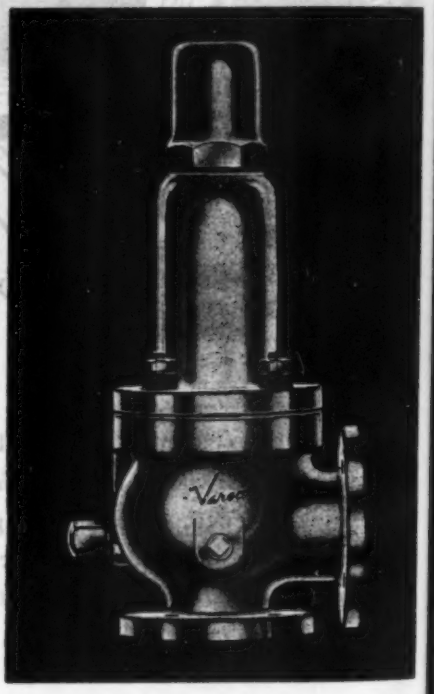


liquids are changed; and there is less fire hazard with inflammable liquids. The cabinet is 24 inches high, 18 inches wide, and 9 inches deep.

For further information write Engineering Research and Development Company, Hinsdale, Ill., referring to PETROLEUM REFINER item 81.

82—Angle Relief Valve



Design of the new Verec nozzle-type angle relief valve, manufactured by Vapor Recovery Systems Company, 2820 Alameda St., Compton, Calif., permits uniformly successful operation in handling the high pressures and temperatures encountered in the petroleum and chemical industries. "A sturdy, high capacity, top guided valve featuring an accurate spring action, easy adjustment, low percentage of blow-down and low maintenance costs," this angle relief valve is available in various sizes and material combinations. Cap is furnished as standard equipment and handwheel is available instead of cap upon special order.

For further information write the company referring to PETROLEUM REFINER item 82.

83—Drum Carrier

The Tray-Hart "Twin" drum carrier is now in production "in response to industry requests for a two-drum companion to the Tray-Hart four-drum carrier" (page 242, April REFINER. The "Twin" is built to the same standard as

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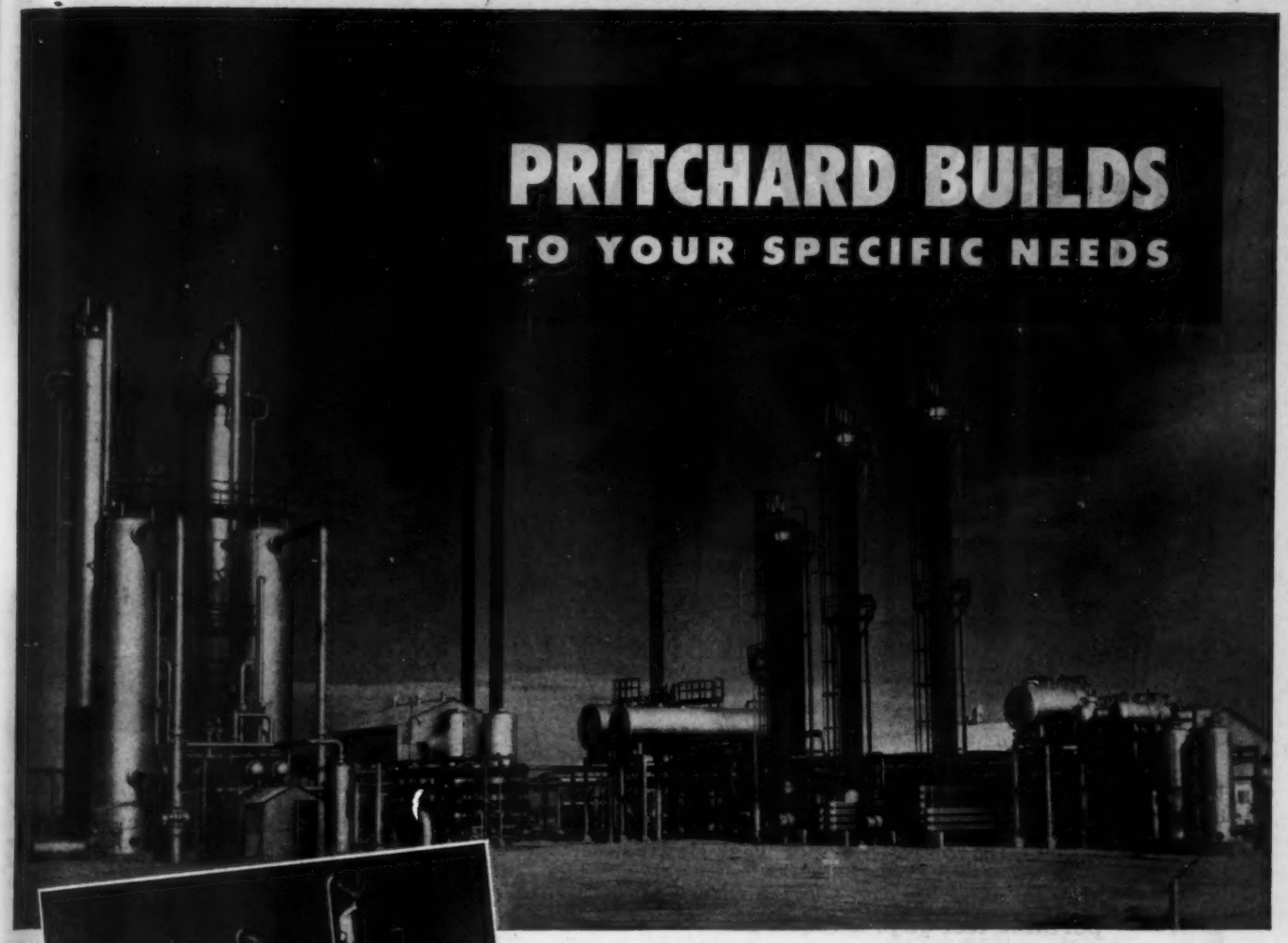
TO YOUR SPECIFIC NEEDS



The installation (shown above), designed and constructed to extract gasoline from natural gas, has recently been completed by J. F. Pritchard & Co., Petroleum Division.

Accumulated experience from many plants engaged in field processes, as well as refining functions, uniquely qualifies Pritchard engineers to handle *all* elements of your project. Refining experience includes:

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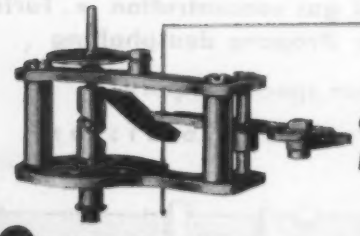
Long, stainless steel (18-8) shank, with square and with 1/4" male pipe thread.

Accuracy guaranteed to within 1/2 of 1%.



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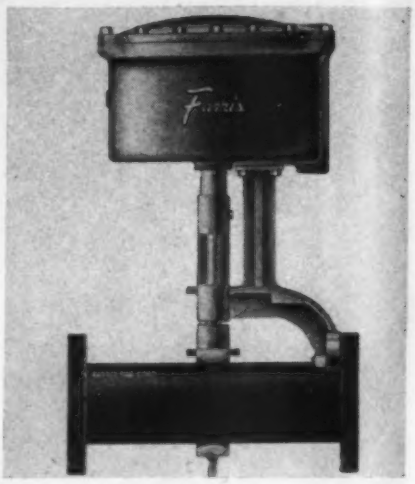
the "Four," the only difference being in capacity. All Tray-Hart multiple drum carriers are especially adapted to speed loading trucks and freight cars as well as in-plant lifting, transporting and stacking drums. The "Twin" is designed for use with any 2000-pound fork truck.

For additional information write Trayner-Reinhart, 1627 Willow Street, Oakland 7, Calif., referring to PETROLEUM REFINER item 83.

84—Pinch Valve



Automatic controls for use with a new type of pinch valve, announced by Farris Engineering Corporation, makes "the first time this fundamental theory of valve controls has been offered in both hand operated and automatic types, including relief valves."

A springless dual drive operating mechanism is featured. Stated simply, in the dual drive, no appreciable force or energy is consumed in doing the useless work of compressing a spring. The drive is piston operated with dual opposing pistons operating with the same loading conditions and with the same controlled movement. No packing glands are employed. Remote operation can be obtained by either of two methods, both offered for off-on control, and in the case of a basic instrument type, for non-precise throttling. A further modification of the springless dual drive is introduced as the Type 7500 Relief Valve.

For additional information write Farris Engineering Corporation, 484 Commercial Avenue, Palisades Park, N. J., referring to PETROLEUM REFINER item 84.

85—Castable Refractories

Johns-Manville announce the development of two new castable refractories for service temperatures up to 3000° F. that "offer substantial savings in furnace construction costs because of their adaptability for application by casting, gunning and troweling." 3X Firecrete, handled as easily as ordinary concrete, it is claimed, is recommended for casting or pouring all special refractory shapes —burner blocks, door linings, furnace covers, and complete linings. 3X Blazecrete was especially developed for pneumatic application in which it is "shot" in place by compressed air with guns. It also can be readily troweled in place. These new refractory products "help reduce outage hours in furnaces because they air harden quickly and can be ready

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THE ALL-AROUND
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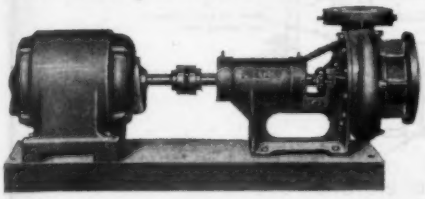
CENTRIFUGAL PUMP

HEADS: *Up to 270 feet*
DRIVES: *Fractional to 20 hp*
CAPACITIES: *Up to 1000 GPM*



Type PB direct-connected to standard motor

Durability — Economy — Plus
Wide Utility for
a Multitude of Services

FACTORIES

The versatile Peerless Fluidyne is pumping simplicity at its best. Peerless FLUIDYNE Type PE (Electric drive unit) or the Type PB (direct connected, V-belt or flat belt drive unit) are designed for vertical, horizontal or intermediate angle installations, with consistent and dependable high efficiency operation. *Completely described in Bulletin B-165.*

SYSTEM SUBASSEMBLIES

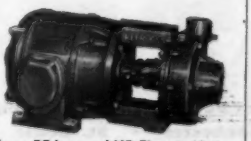
FLUIDYNE FRACTIONAL HP PUMPS ¼ TO 1 HP
CAPACITIES: *10 to 50 GPM*
HEADS: *20 to 95 ft.*

BUILDINGS

Possessing all characteristics of the Types PE and PB pumps described above, these fractional Fluidyne Peerless Pumps may be coupled to motor for incorporation into any system requiring forced liquid circulation. All Fluidyne pumps are of end suction, single stage

FOOD PACKERS

design with vertical split casing joint, and embody a host of features for ease of accessibility and maintenance. *Completely described in Bulletin B-150 and B-151.*



Type PE Integral HP Electric Unit

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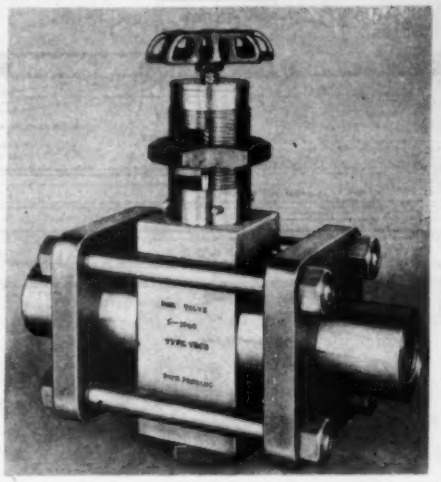
for service within 24 hours after installation." Both are said to have negligible shrinkage from application to soaking temperatures of 3000° F. and possess unusually high spall resistance.

For further information write Johns-Manville Corporation, 22 East 40th Street, New York, referring to PETROLEUM REFINER item 85.

86—Blow-Down Valve



Based on the new venturi ball valve principle, the Paul continuous blow-down valve is said to be ideal for rigorous continuous boiler blow-down service. With ony two moving parts and no springs, this valve utilizes the Bernoulli theorem to force a precision ball into the low-pressure center of the stream, and hence into the seat. The body of the valve is machined to the shape of a venturi tube. The valve tends to close automatically whenever water or steam flow through the venturi. Hard Stellite inlet and outlet bushings, incorporating the seats, and a hard Stellite ball make the parts subject to the greatest wear as resistant as possible. Other valve parts are supplied in high chromium stainless steel.

The valve is of the outside screw and yoke type. Type VBCB, 1500-pounds series is available in sizes from ¼ to 1 inch, conforming with inside dimensions of Schedule 80 pipe.

For further information write Paul Valve Corporation, 683 Third Avenue, New York 17, referring to PETROLEUM REFINER item 86.

87—Reflectroscope

Operation and application of the Sperry portable, lightweight TypeSR05 supersonic reflectoscope is described in Bulletin 3001.

For a copy write Sperry Products, Inc., 1505 Willow Avenue, Hoboken, N. J., referring to PETROLEUM REFINER item 87.

88—Electric Motors

Information on Allis-Chalmers general purpose motors is contained in "Handy Guide for Quick Selection of Electric Motors" which provides detailed specifications covering squirrel-cage induction motors and application data, range of sizes and speed torque curves on synchronous, wound rotor and direct current motors. It covers applications and features of gearmotors and multi-speed induction motors and

. . . but the designing of a pin calls for the services of very few skills, whereas the designing of an oil refinery or a chemical plant demands a FORMIDABLE ARRAY OF SKILLED MANPOWER.

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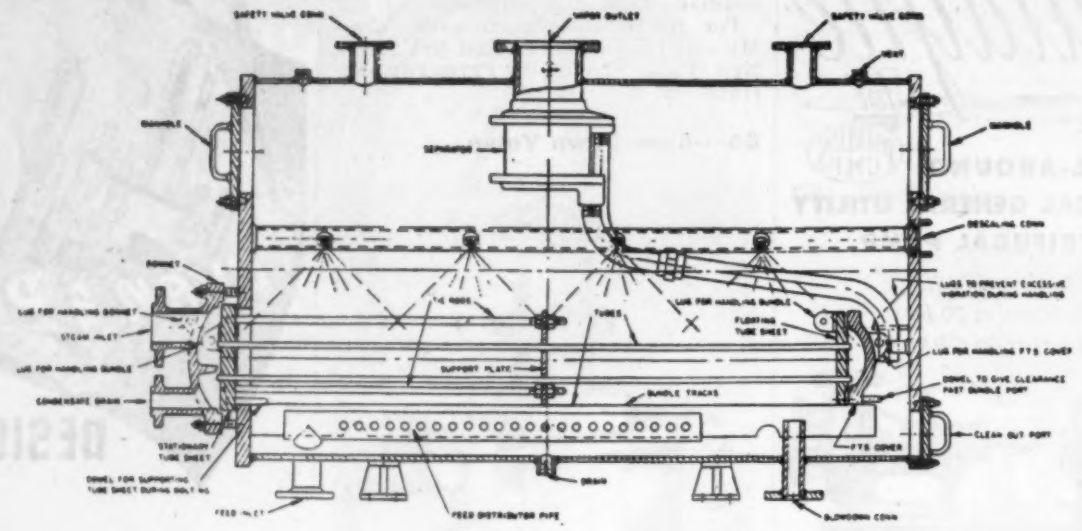
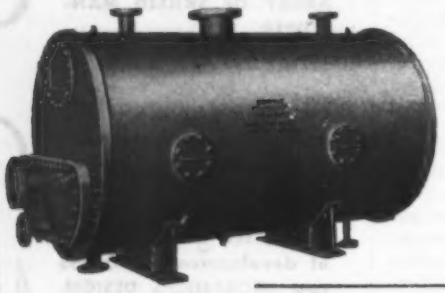


Sectional elevation of a
Lummus Power Plant Evaporator



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for operation and maintenance

Pure water from any raw or salt water supply

Lummus experience . . . in designing and fabricating power plant evaporators to meet individual requirements . . . is your guarantee of a dependable supply of pure water from any raw or salt water source.

Full-efficiency operation is assured by a soundly based design that provides adequate vapor separators and liberal, properly balanced disengaging areas. Easy maintenance is assured by a practical understanding of field conditions. All connections are readily accessible and do not require disassembly within the unit to remove the tube bundle.

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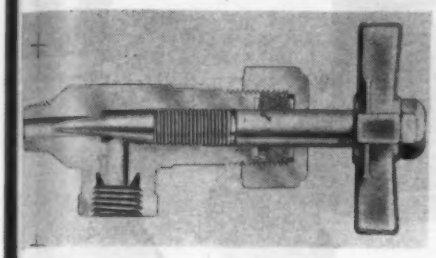
carries an induction motor selection chart for units from one to 200-horsepower.

For copies of the guide write Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis., referring to PETROLEUM REFINER item 88.

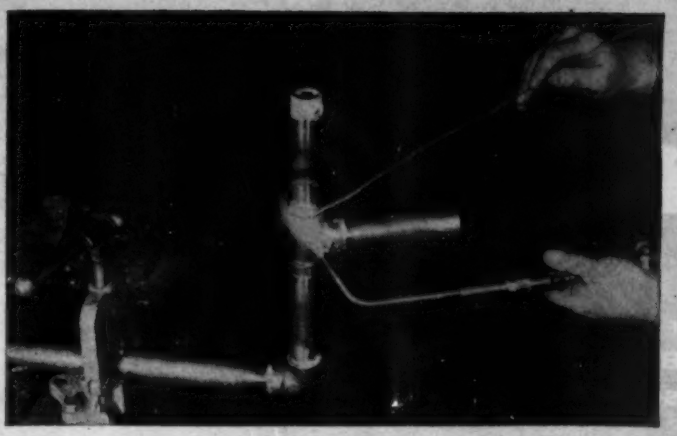
89—Micrometer Needle Valve



A specially designed needle valve for the sensitive metering of fluids and gases has been developed by The Parker Appliance Company. This is a modification of the company's compact, forged-body industrial valve design, but has 5/16-inch -40 stem threading for close adjustment, and a long 10° included angle tapered needle for fine metering. The standard valve is of high-strength brass, but aluminum alloy bodies can also be supplied. It is available in ⅛ and ¼-inch sizes, with eight port combinations of male and female, pipe and tube connections.

For additional information write The Parker Alliance Company, 17325 Euclid Avenue, Cleveland, Ohio, referring to PETROLEUM REFINER item 89.

90—Threadless Fittings



Brazing is simple on Flagg-Flow joint.

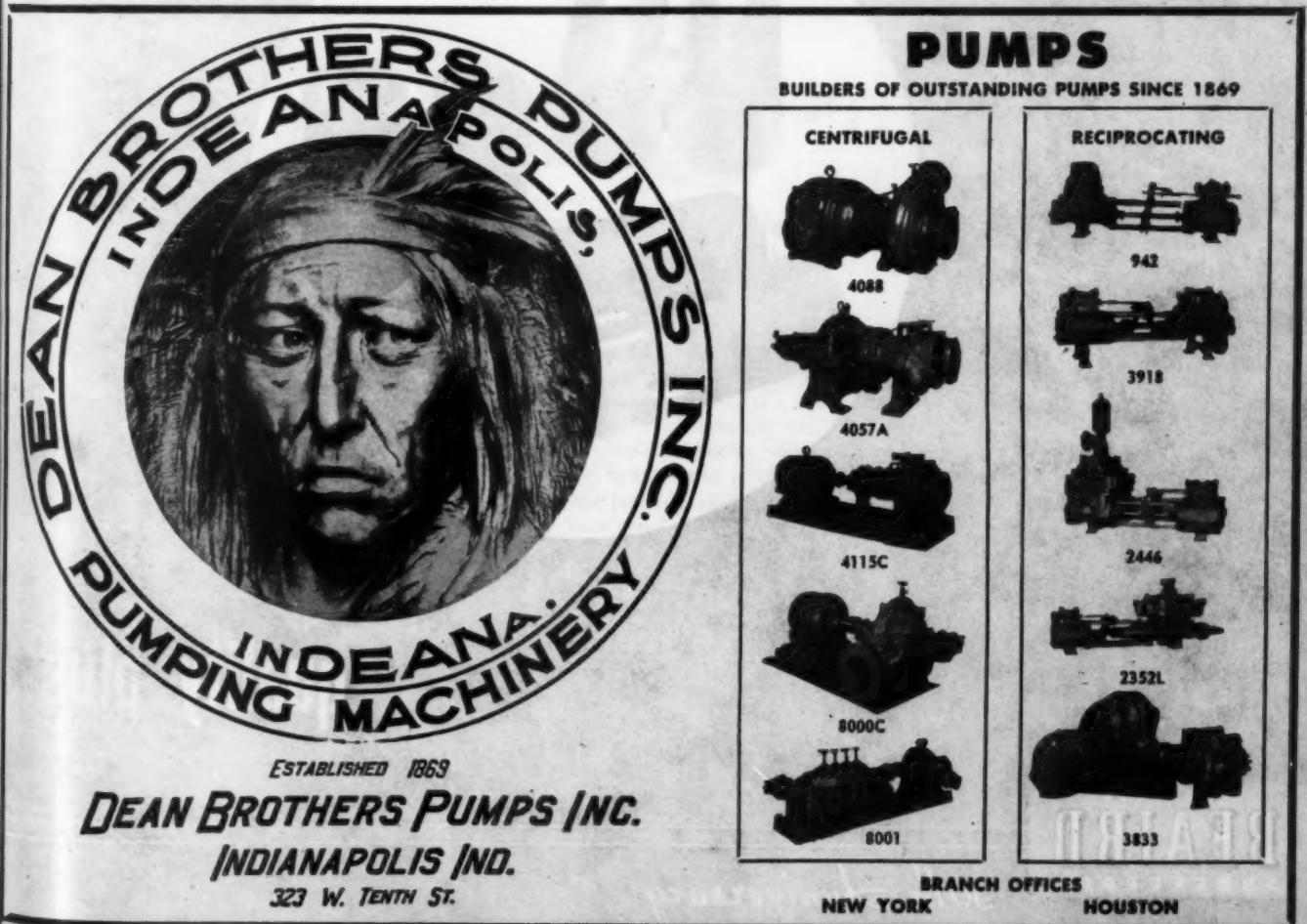
Flagg-Flow threadless fittings have been designed to meet the demand for one-piece brass, copper pipe or copper tubing. They are threadless bronze pipe fittings for brazing to I.P.S. brass or copper base alloy tubing or pipe, and the one-piece system that results, is as strong as the pipe itself, yet easy to install at low cost. The fittings are applicable for 150-pound working steam pressure lines at 450° F., or 300-pound non-shock cold water, oil, or gas lines. Flagg-Flow bronze fittings are used on hot and cold water lines, steam piping, fuel oil piping, on meter and instrument lines, lubricating oil piping, gas and air piping, boiler feed lines, hydraulic systems of not over 300 pounds, and in process piping where brass, copper pipe or tubing is applicable. Bronze threadless fittings can also be used in air, oil, and water systems in the transportation field.

For further information write Stanley G. Flagg & Company, 1421 Chestnut Street, Philadelphia 2, referring to PETROLEUM REFINER item 90.

91—Thermometer Element

A bonded wire resistance thermometer element characterized by stability, accuracy and rapid response, announced by Ruge-de Forest, is known as "RdF Stikon," and consists of a grid of fine nickel wire bonded into a paper-thin bakelite wafer. Bakelite cement is used to attach the wafer to the surface whose temperature is to be measured. These elements are within the tolerances permitted by the Army-Navy Specifications for electrical resistance thermometers, and will operate into standard indicators, recorders, and controllers.

Stikon will operate in continuous



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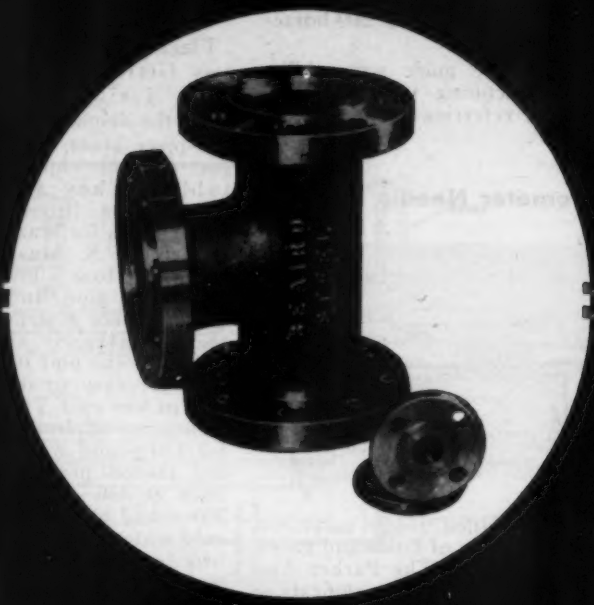
BEAIRD-BUILT PRODUCTS
SOLD "ROUND THE WORLD"



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SINCE 1931
BEAIRD
SHREVEPORT

30th Anniversary

SHREVEPORT, LOUISIANA

service in temperatures from —40°F to +30°F.

For additional information write Rugede Forest, 76 Massachusetts Avenue, Cambridge 39, Mass., referring to PETROLEUM REFINER item 91.

92—Hydraulic "O" Ring

Crane Packing Company announces availability of a bulletin "John Crane Hydraulic 'O' Rings," which contains tabulations of compound specifications; dimensional standards—and data on applications, installations, etc., plus drawings showing typical problems of "O" ring usage.

For a copy write Crane Packing Company, 1800 Cuyler Avenue, Chicago 13, referring to PETROLEUM REFINER item 92.

93—One-Man Fire Truck

One-man operation of a foam-producing, fire-fighting, double-duty truck for protection of oil risks is claimed by National Foam System, Inc. The powerful mobile unit, employs the latest fire protection techniques and could produce sufficient foam immediately at the scene of action to extinguish fire in an 80,000-barrel tank. Each new National Foam truck is engineered for its specific purpose and can be designed in any capacity from 2500 gpm. of foam to 12,000 gpm. Each truck also serves as a regular water pumper.

For further information write National Foam System, Inc., Philadelphia, referring to PETROLEUM REFINER item 93.

94—Valve Packing

Catalog section 12-R, describes all types of EValpak die molded packing, which is furnished in sets with each set containing two types of packing. The top and bottom, or outer, rings of each set are wire inserted jacketed rings while the center rings are die molded plastic rings.

For a copy write Edward Valves, Inc., East Chicago, Ind., referring to PETROLEUM REFINER item 94.

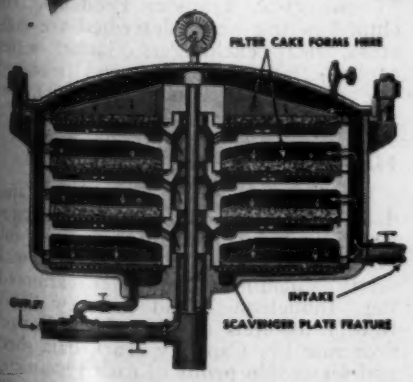
95—Anti-Corrosion Coating

Minnesota Mining & Manufacturing Company, Adhesives and Coatings Division, 411 Piquette Avenue, Detroit 2, in "3M Adhesives in Industry" describes this anti-corrosion coating for use on tanks for storing sour crude oils.

Sparkler Filters

SPARKLER horizontal plate FILTERS

. . . keep petroleum products clean and free of foreign matter



The Sparkler horizontal plate method of filtration insures a firm, unbroken filter cake formed from diatomaceous earth or other filter media particularly suited to the liquid filtered. Such a filter cake removes even microscopic particles from any liquid ranging from light alcohols to heavy resin products.

The petroleum refining and processing industry have available a filter in the Sparkler that solves many problems of keeping liquid petroleum products free from solids such as scale, rust, grit, and other foreign matter.

Domestic Fuel Oil bulk plant operators can be sure of delivering clean clog-free fuel oil by filtering with Sparkler filters

Sparkler filters are available in capacities from small pilot plant models to built-in production line units of 5000 gallons per hour. The services of our staff of engineers with over a quarter of a century experience in solving filtration problems is available. Your problems will receive personal attention and individual analysis. Write Mr. W. J. Kracklauer, Sec'y & Treas.

SPARKLER MANUFACTURING COMPANY, Mundelein, Illinois

KEEP BLACK CLOUDS OUT OF THE SKY

BLAW-KNOX
FOG NOZZLES AND AUTOMATIC SPRINKLERS

. . . are standard protection against fire in refineries and other oil industry installations.

They strike back at fire with the speed of lightning. They smother fire with a blanket of fog while their powerful spray reaches to the base of the fire, cooling and quenching inflammables and fuel.

The Blaw-Knox Fog Nozzle has wide free-flowing passages without screens. It is non-clogging—always instantly available—and one of fire's worst enemies.

Send for Bulletin No. 2207

Listed by Underwriters' Laboratories, Inc. Approved by Factory Mutual Laboratories.

Blaw-Knox offers Standard Wet and Dry Pipe Systems, as well as Thermostatically Controlled Deluge Systems.

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SPRINKLER DIVISION
OF BLAW-KNOX CONSTRUCTION COMPANY
829 Beaver Ave., N. S.
Pittsburgh 12, Pa.
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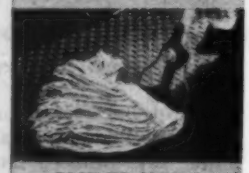
AW SUPER-DIAMOND FLOOR PLATE

GIVES YOU THE EXTRAS AT NO EXTRA COST

TODAY, stationary and mobile equipment designers and manufacturers are specifying AW Super-Diamond Floor Plate for all surfaces on their products, on which men walk or climb. The exclusive AW Super-Diamond Pattern provides *extra* safety for workers which ordinary floor plate does not offer. It grips without a slip preventing costly slipping accidents. It's extra economical—the first cost is low and there is no maintenance cost. Follow the example of leading designers and specify AW Super-Diamond Floor Plate for your products. Write for complete information, and a copy of our catalog.

GRIP WITHOUT A SLIP!


EASY TO CLEAN!

EASY TO MATCH!

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AW SUPER-DIAMOND
FLOOR PLATES THAT GRIP

Alan Wood Steel Company, Conshohocken, Pa.

Please send me a copy of your informative catalog L-52

Name_____

Company_____

Address_____ City_____ State_____

A Product of ALAN WOOD STEEL COMPANY
Other Products: Billets • Plates • Sheets • Carbon & Alloy

96—Surface Condensers

The Condenser Department of Elliott Company, has published Bulletin C-9 on its Type F surface condensers. Built in sizes from 500 to 15,000 square feet, this type is available in both divided and non-divided water-box types. Included are data on condensate pumps, steam jet ejectors, duplex drainers, air leakage meters, as well as a pressure-temperature conversion table, chart for determining logarithmic mean temperature differences, and condenser formulas.

For a copy of the bulletin write Elliott Company, Jeanette, Pa., referring to PETROLEUM REFINER item 96.

97—Scrubbers and Coolers

Bulletin H-203, on gas scrubbers and coolers has been released by Peabody Engineering Corporation, New York City, N. Y. Complete with diagrammatic sections, illustrations explaining both a multi-stage and a single-stage scrubber and cooler, the bulletin also carries diagrams of impingement baffle-plate action and actual performance.

For a copy write Peabody Engineering Corporation, 580 Fifth Avenue, New York 19, referring to PETROLEUM REFINER item 97.

98—Tube Steels

The Babcock & Wilcox Tube Company has a bulletin on B & W Croloys giving technical data on high-temperature steels for alloy tubes and pipe. Offered is condensed information in chart form on such factors as creep strength, short time tensile strength, oxidation and corrosion resistance, temper embrittlement and minimum physical properties.

The bulletin may be had by writing to The Babcock & Wilcox Tube Company, 85 Liberty Street, New York 6, referring to PETROLEUM REFINER item 98.

99—Heat Transfer

Young Radiator Company of Racine, Wis., describes the entire Young line in its new general catalogue 148, entitled, "Young Heat Transfer Products." Included in the items described are radiators, heat exchangers, jacket water coolers, large capacity and standard size cooling and condensing units, and specialized products.

100—Rotameters

Brooks Rotameter Company, Lansdale, Pa., has issued a full new catalogue which includes descriptions of its full line of rotameters ("Full-View" with safety shielding, "Stain-Met" armored, the "Inductronic" and the new "Sho-Rate") as well as the "Multi-Range" flow rate kit. Capacity chart, data sheet and dimension prints of each type meter are included. Refer to PETROLEUM REFINER item 100.

101—Corrosion Resisting Alloys

Bulletin 114 on nickel-molybdenum and nickel - molybdenum - chromium alloys introduced about two years ago by The Duriron Company, Inc., includes much information on the new Durco alloys, Chlorimet 2 and Chlorimet 3, not previously available. Particular attention is given to its use for sulfuric acid, hydrochloric acid and salt solutions, and on how it supplements other alloys for

these corrosives. Many charts are included on corrosion resistance tests. One hundred and twenty corrosives are dealt with.

For full information, write to The Duriron Co., Inc., Dayton 1, Ohio, referring to PETROLEUM REFINER item 101.

102—pH Recorder

Bulletin ND 44-96-702(1) issued by Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia 44, features equipment which is said to enable refinery operators to "see" the pH of dehydrator water simply by glancing at the indicating scale of a Micromax recorder. This publication describes and illustrates the L&N glass electrode assembly and there are also descriptions and photographs of the Model S strip-chart recorder.

When writing for bulletin refer to PETROLEUM REFINER item 102.

103—Chemical Additives

"Chemical Additives for Petroleum Lubricants," a booklet prepared by American Cyanamid Company, explains in non-technical language what additives are, why they are needed, when and where they are used, and how they improve lubricating oils. Covered are all of the commonly used types of lubricating oil additives.

For a copy write American Cyanamid Company, 30 Rockefeller Plaza, New York 20, referring to PETROLEUM REFINER item 103.

104—Steel Fabrication

Fractionating towers, absorbers, scrubbers, heat exchangers and all types of pressure vessels designed for the petroleum and chemical industries and constructed by Superior Manufacturing Company are described in the company's new brochure. Pipe fabrication, another specialty, also is included and interesting photographs are presented showing various jobs being processed or already finished.

For a copy of this brochure write Superior Manufacturing Company, Amarillo, Texas, referring to PETROLEUM REFINER item 104.

105—Construction Guide

An engineering bulletin (No. 97) giving detailed recommendations on construction materials for almost 400 different corrosive liquids and gases has recently been published by Fischer & Porter Company, Department IC-L, Hatboro, Pa.

The bulletin was designed specifically for selecting materials to be used in F&P's "Flowrator" instruments for measuring flow of corrosive fluids. Therefore material recommendations are listed under three headings having particular reference to "Flowrator" instrument construction features.

When writing for bulletin refer to PETROLEUM REFINER item 105.

106—Corrosion Bulletin

Causes and control of contamination in the petroleum industry are covered in two new Amercoat descriptive bulletins, one covering production and drilling, the other refining. Complete, factual, concise data is given on more than sixty difficult exposures and definite recommendations made for each. How

ANSUL MODEL 350 A

THE MASTER OF FLAME
ANSUL
REG. U.S. PAT. OFF.
FIRE EXTINGUISHING EQUIPMENT

DRY CHEMICAL
FIRE EXTINGUISHERS

give you MORE PROTECTION per dollar

Ansul Dry Chemical Fire Extinguishers give you more protection . . . pound for pound . . . dollar for dollar . . . than any other extinguisher of comparable size. In addition . . . Ansul Fire Extinguishers provide the best first-aid protection:

- For hazards involving flammable gases, gasolines, alcohols, solvents, oils, asphalts and greases.
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Ansul Fire Extinguishers have the highest established ratings for effectiveness on flammable liquid fires, based on tests by nationally recognized approval agencies. The longer range stream of dry chemical is effective in winds and drafts.

After use, Ansul Dry Chemical Fire Extinguishers can be recharged "on the spot" . . . providing continuing protection . . . and annual recharging of Ansul extinguishers is NOT necessary.

Safe to use . . . non-toxic, non-corrosive, non-abrasive.

Ansul Dry Chemical Fire Extinguishers are preferred fire protection in the production, refining and marketing of all petroleum products.

Ask for your copy of file No. 225. You will receive factual data on how Ansul Dry Chemical Extinguishers will cut your fire protection costs.

Listed and Approved by Underwriters' Laboratories and Factory Mutual Laboratories.

ANSUL CHEMICAL COMPANY
FIRE EXTINGUISHER DIVISION, MARINETTE, WISCONSIN
DISTRIBUTORS IN ALL PRINCIPAL CITIES

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THERE'S ONE HEAT EXCHANGER...

TO BEST FIT YOUR JOB

At Whitlock, the MECHANICAL DESIGN of your heat exchanger is the result of practical, down-to-earth engineering based on a thorough understanding of your own particular operating conditions. Whitlock applies sound MECHANICAL DESIGN which interprets customer requirements theoretically and practically while complying explicitly with specified Codes. Whitlock's MECHANICAL DESIGN goes a step beyond Codes, however, analyzing every aspect of the design to make doubly sure the unit will accomplish everything desired of it. Material selection, material thickness, joint designs, welding technique, metallurgical requirements, test and inspection are but a few of the details making up this proper MECHANICAL DESIGN—whether the conditions are routine or whether they involve extremes of operating temperature and pressure.

Correct MECHANICAL DESIGN is one of the important factors that make Whitlock heat transfer equipment "right in every way."

WHITLOCK HEAT TRANSFER EQUIPMENT

Right IN EVERY WAY

1. Thermal Design
2. MECHANICAL DESIGN
3. Material Selection
4. Quality Fabrication
5. Cost Economies

It pays to watch these unseen factors

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NEW YORK • CHICAGO • BOSTON • PHILADELPHIA • DETROIT
RICHMOND • Authorized representatives in other principal cities.
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WHITLOCK DESIGNS AND BUILDS Bends • Coils • Condensers • Heat Exchangers Heaters • Piping • Pressure Vessels • Receivers • Reboilers

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to prevent corrosion of perco sweetening systems, acid sludge tanks, buildings and dozens of other surfaces is described.

For a copy write Amercoat Division, American Pipe and Construction Company, P. O. Box 3428, Terminal Annex, Los Angeles 54, referring to PETROLEUM REFINER item 106.

107—Thermometers

Wm. Hiergesell & Sons, announce the availability of Herco Bulletin 208 which lists the 1948 and latest revised specifications of ASTM thermometers.

For a copy write Wm. Hiergesell & Sons, 295 Pearl Street, New York 7, referring to PETROLEUM REFINER item 107.

108—Protective Coatings

A folder showing how to cut costs in areas where corrosion is a problem includes many case histories in different types of industries which are using Prufcoat coatings. Equipment, walls, floors, etc., are shown protected against corrosion from acids, alkalies, oil, and water.

For a copy write Prufcoat Laboratories, Inc., 63 Main Street, Cambridge, Mass., referring to PETROLEUM REFINER item 108.

109—Gages

Improvements in Bourdon tube design and gage movements which increase the working range of Heise pressure gages, are featured in a new catalog. Top working pressures for measurements of engineering accuracy have been increased from 3000 to 10,000 psi. within a relatively few years and the Heise company offers gages for pressures above 10,000, but explains that the accuracy in the higher ranges may not equal that of the standard ranges.

For a copy write Heise Bourdon Tube Company, Inc., Newton, Conn., referring to PETROLEUM REFINER item 109.

110—Blowers, Fans, Exhausters

General Blower Company has issued a brochure describing its line of blowers, fans and exhausters for blowing, heating, cooling, conveying, aerating, separating and agitating. Photos of different pieces of equipment and installations are included.

For a copy write General Blower Company, Morton Grove, Ill., referring to PETROLEUM REFINER item 110.

111—Oil Burners

Peabody Engineering Corporation, 580 Fifth Avenue, New York 19, has issued two new bulletins on oil burning equipment. Bulletin 111 describes Peabody oil burners with the wide-range mechanical atomizing feature and Bulletin 205 describes the combination gas and oil burners.

When writing for bulletin refer to PETROLEUM REFINER item 111.

112—Diamyl Phenol

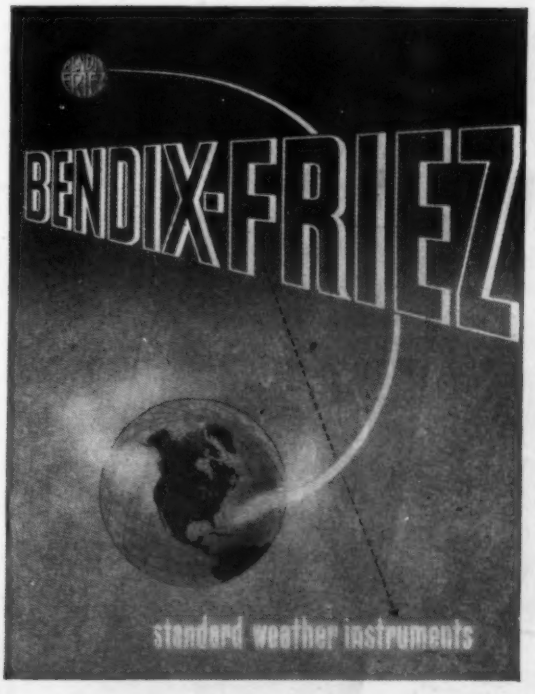
Koppers' Chemical Division has issued Bulletin C-8-110 describing the properties, uses, and reactions of diamyl phenol. The physical and chemical properties of the compound are described, and included is a bibliography of 104

BENDIX FRIEZ

Symbol and Source

of America's Foremost Weather Instruments

Whether you require a single meteorological instrument or a complete weather station, Bendix-Friez can meet your need with equipment that is the acknowledged standard for accuracy and advanced design. Write for our 48-page catalogue which lists, illustrates and describes scores of instruments useful to industry.



NATIONAL AIR RACES CLEVELAND SEPT. 4-5-6
BENDIX TROPHY RACE SEPTEMBER 4

FRIEZ INSTRUMENT DIVISION
OF BENDIX AVIATION CORPORATION
Baltimore 4, Maryland

PRODUCT OF Bendix AVIATION CORPORATION

It's HARPER
Everlasting Fastenings

10 TO 1
OVER COMMON STEEL

RESISTANCE TO RUST AND CORROSION
NON-MAGNETIC
NON-SPARKING
RESISTANCE TO HIGH TEMPERATURES
RE-USABLE
ATTRACTIVE APPEARANCE
EASY TO CLEAN
HIGH STRENGTH
LONG SERVICE LIFE
LOWER ULTIMATE COSTS

LOWER FIRST COST

Prompt Shipments from Stock . . . Bolts, Nuts, Screws, Washers, Rivets, Accessories . . Harper maintains stocks of over 5,000 different items in Chicago and New York . . large quantities of each. Others being added constantly. Specials made to order from ample stocks of new metals. Write for Catalog.

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2663 Fletcher St., Chicago 18, Ill.
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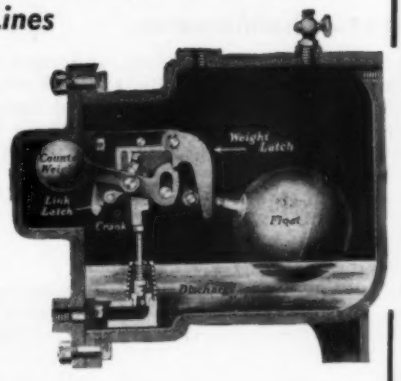
Atlanta, Cambridge, Cincinnati, Cleveland, Dallas, Denver, Detroit, Grand Rapids, Los Angeles, Miami, Milwaukee, Philadelphia, St. Louis, San Francisco, Seattle.

HARPER

Nicholson Weight-Operated Traps

STOP Corrosion Trouble

Promote Positive Drainage of Steam, Gasoline, Air Lines



All internal parts of Nicholson weight-operated traps are made of stainless steel or bronze, carefully selected to give permanent resistance to the corrosion problems arising in gasoline, steam and air lines. Other trouble-free features resulting in the adoption of Nicholson traps as standard by an increasing number of large trap users: positive fluid seal keeps valve tight; not easily affected by dirt, pulsation, pressure variations; non wire drawing; rugged to take unavoidable abuse.

Traps for Every Industrial Application

Three types for all pressures to 1500 lbs. also thermostatic and expansion traps for steam pressures to 225 lbs. CATALOG 448.

W. H. NICHOLSON & CO. 207 OREGON STREET WILKES-BARRE, PA.

Valves ★ Traps ★ Steam Specialties

THIS CATALOG WILL SAVE YOU $$

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references relating to the chemical reactions and uses of the chemical.

For copies write Koppers Company, Inc., Chemical Division, Koppers Building, Pittsburgh 19, Pa., referring to PETROLEUM REFINER item 112.

113—Insulating Roof Tile

A booklet describing the physical properties and construction specifications of the new Kaylo insulating roof tile is ready for distribution. This tile is easy to install and combines fire resistance, structural strength, and insulation in a single roof deck material. Its light weight makes possible roof decks with a dead load (above the main purlins) of twelve pounds or less per square foot.

For a copy of the booklet write American Structural Products Company, Toledo 1, Ohio, referring to PETROLEUM REFINER item 113.

114—Stainless Steel

Bulletin 112 has been issued by The Duriron Company, Inc., Dayton 1, Ohio, on a high alloy low carbon austenitic stainless steel known as Durimet 20. Introduced just before the war, this alloy has proved to be markedly superior to standard 18-8 stainless steel analyses for certain severe corrosive services, especially in the handling of sulfuric acid. It is recommended for use with about 125 corrosive solutions.

When writing for the bulletin refer to PETROLEUM REFINER item 114.

115—Turbine and Pumps

Two new bulletins are offered by Worthington Pump and Machinery Corporation. Bulletin 1961 describes the Worthington multi-stage steam turbine type "S" with variable speed oil relay governor.

Bulletin W-305-B1 describes centrifugal pumps, types CN and CNE, for belt, multi-v-drive, and motor drive. This bulletin describes the installation, ratings and dimensions of these pumps.

For copies of these bulletins write Worthington Pump and Machinery Corporation, Harrison, N. J., referring to PETROLEUM REFINER item 115.

116—Tank and Line Heaters

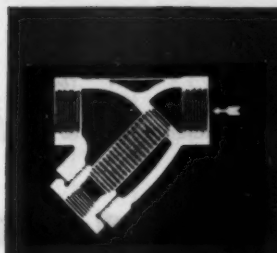
The Brown Fintube Company's bulletin No. 482 describes its tank suction heaters, line suction and line pressure heaters. The tank heaters are designed to heat viscous oils being withdrawn from bulk storage tanks so the oil can be pumped more readily. The line suction and pressure heaters are designed and used, either to preheat liquids for further processing, or to overcome temperature losses in long lines.

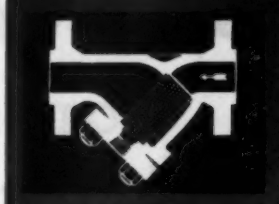
For a copy of this bulletin write The Brown Fintube Company, 150 Huron Street, Elyria, Ohio., referring to PETROLEUM REFINER item 116.

117—Cranes and Shovels

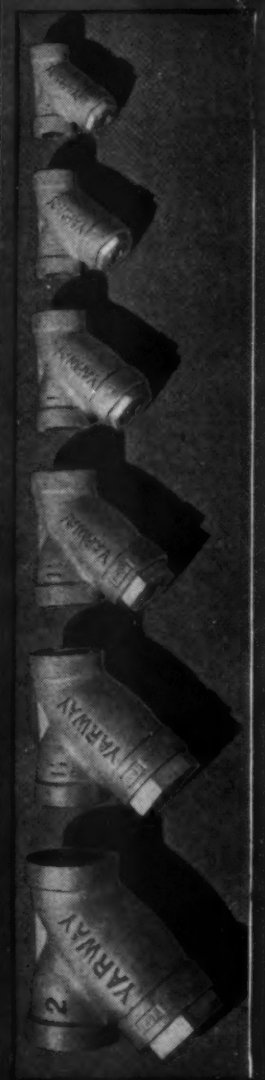
A booklet, describing varied uses of power cranes and shovels in the petroleum field, has just been published by The Thew Shovel Co., Lorain, Ohio. Titled "Lorains in the Petroleum Industry," the book explains the applications of Lorain equipment to petroleum problems "from production to refinery."

When writing for booklet refer to PETROLEUM REFINER item 117.


SCREWED-END STRAINER


FLANGED-END STRAINER

"Pipeline Policemen"



A good strainer protects your equipment and pipeline.
These little Yarway "guardians of the pipelines" have literally taken industry by storm. In the few years since their introduction, hundreds of thousands have been bought . . . are daily giving top satisfaction in a variety of services.

HERE ARE SOME OF THE REASONS:

- SCREEN—a high-grade woven monel wire basket that catches solids—lets condensate, oil or other fluids flow freely. Perforated screens if desired.
- SCREEN CAP—easily removed. Cap and screen come out together. Screen automatically aligns when replaced. Machined face and spark-plug-type gasket provide tight joint.
- BODY—rugged iron or steel, cadmium-plated for protection against corrosion and for better appearance.
- SIX SIZES—½" to 2" for pressures up to 600 lbs.
- AVAILABILITY—stocked and sold by 150 Mill Supply Houses. Reasonably priced.
- See your local dealer or write for Bulletin S-201.

YARNALL-WARING COMPANY
128 Mermaid Avenue Philadelphia 18, Pa.

YARWAY STRAINERS
"Police the Pipelines"

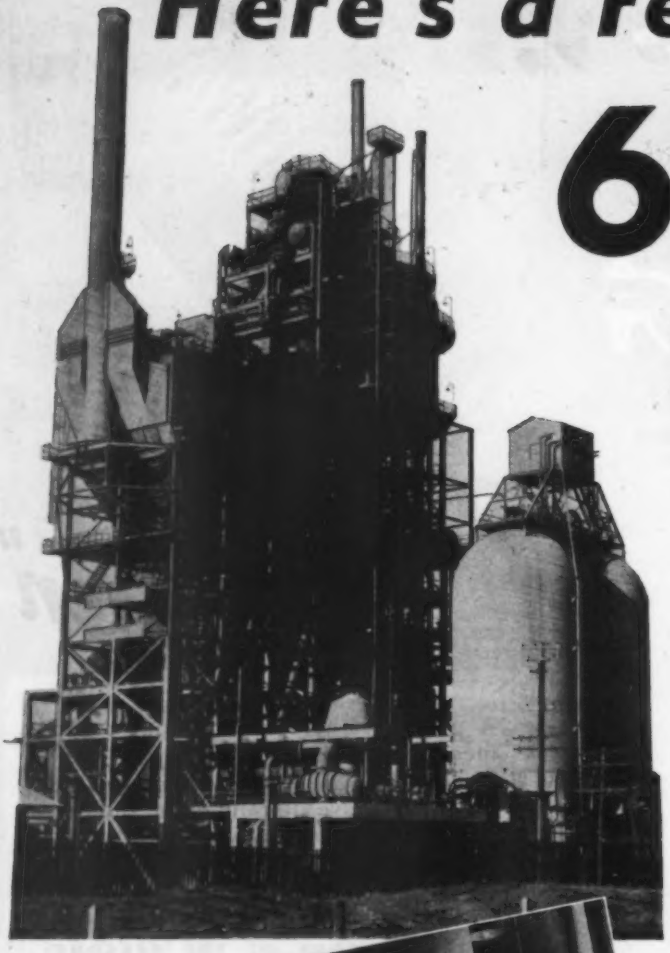
Here's a real record!

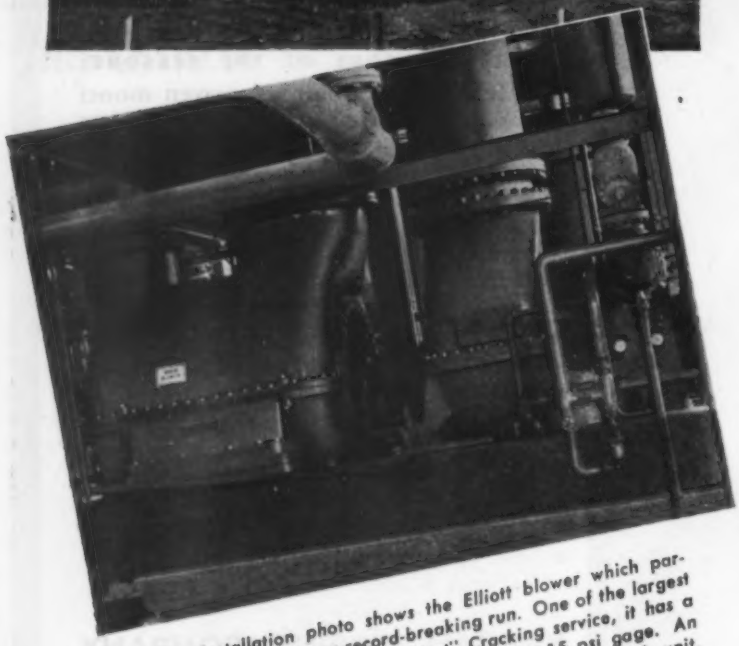
610½ days

non-stop for this "cat cracker" and its

Elliott

BLOWER





This installation photo shows the Elliott blower which participated in the Avon record-breaking run. One of the largest turbo-blowers ever built for "cat" Cracking service, it has a capacity of 55,000 cfm and discharges at 15 psi gage. An Elliott 4500-hp steam turbine drives this powerful unit.

It happened at the Tide Water Associated Oil Company's Avon, California refinery—a new record of 14,640 hours of continuous on-stream operation. A real achievement for the "cat cracker" and its equipment which stood up under the long grueling service.

The big Elliott turbine-driven, multi-stage blower, pictured at the left, contributed its share to this record, as did numerous Elliott turbines in the plant. Just one failure on the part of any of the units could have ruined this record. But the Elliott equipment came through—as usual. The big turbo-blower unit kept right on working smoothly and effortlessly, performing as it was designed to perform — contributing savings instead of maintenance costs.

Elliott turbine or motor-driven blowers are noted for just such service. They are setting non-stop records for smooth, reliable performance in refineries all over the world. A discussion with the Elliott Engineer will give you the specific Information for your own requirement. For complete details, write to Technical Data Department.

P-1091

ELLIOTT COMPANY, Centrifugal Blower Department, JEANNETTE, PA.

Plants at: JEANNETTE, PA. • RIDGWAY, PA. • SPRINGFIELD, OHIO • NEWARK, N. J. • District Offices in Principal Cities

About EQUIPMENT SERVICE SUPPLIERS

Smith Heads De Laval

H. L. Watson has retired as president of De Laval Steam Turbine Company, Trenton, N. J., after 35 years of active service and George W. Smith, Jr., has been named his successor. Watson will continue in the capacities of a director and chairman of the executive committee.

Smith

Before coming with De Laval in 1947 as assistant to the president, Smith was with White Motor Company, Victor Talking Machine Company (now Victor Division of RCA), Bendix Aviation Corporation, Ohio Crank Shaft Company, and as chief engineer of the Naval Aircraft plant at the Philadelphia Navy Yard. More recently he has been engaged in industrial engineering consulting services in New York.

Watson directed the affairs of the company as executive vice president from 1935 to 1942 and as president since 1942.

Gallagher Is Appointed

Walter B. Gallagher, for the past two years their Philadelphia sales representative, has been named sales manager by Greene, Tweed & Company, North Wales, Pa., manufacturers of Palmetto packings. Prior to this association, Gallagher was on the sales staff of the Philadelphia Electric Company. He succeeds Howard Josephson who recently resigned to assume presidency of Howard Asbestos Company.

Vinson Named Ladish Outlet

Vinson Supply Company of Tulsa has been appointed distributor for the entire Ladish line of "controlled quality" fittings and flanges. Vinson formerly carried Ladish stocks, but the appointment now makes it possible for customers to be afforded the complete Ladish line.

Vinson also stocks Nordstrom valves and Stockham valves in large ranges and sizes in the three warehouses. Vinson Supply has been serving refineries, gasoline plants, etc., for the last 25 years.

Elliott Assignments

Elliott Company, Jeannette, Pa., has announced assignment of graduate engineers to district offices, upon their completion of a one-year training course, as follow: F. C. Hohenstein, Chicago; M. C. Seeman, Cleveland; G. J. Greaney, Jr., Houston; J. U. Kauffman, St. Louis, Mo.; R. L. Henry, Tulsa; and W. W. Gotherman to Washington, D. C.

Record Class Commences Bailey Meter Training Work

Bailey Meter Company, Cleveland, Ohio, inaugurated its 1948 Cadet Engineering Class on July 6. The class is one of the largest in Bailey's history with 23 universities and engineering colleges represented. All in the class are graduate engineers with the exception of three, who have completed their junior year in engineering and will return to school in the fall.

The course consists of lectures on the theory of meters and control systems as well as factory training in the assembly and calibration of equipment. Also included is work in the Cleveland main office for experience in the proper application of Bailey equipment as well as practice in drawing up specifications for those applications. They also spend a limited time in the research laboratory.

Upon completion of the course, these engineers will become part of Bailey Meter's staff of resident engineers.

Manufacturer's Representative Firm Is Announced by Ives

Establishment of a new manufacturer's representative organization is announced with the formation of Clifford B. Ives & Company, 1500 Walnut Street, Philadelphia. This company, which will represent Fisher Governor Company, Continental Equipment Company, Daniel Orifice Fitting Company, and others in eastern Pennsylvania, southern New Jersey and Delaware, will be directed by Clifford B. Ives.

After leaving the Worcester Polytechnic Institute, Ives joined Foxboro Company as research and development engineer and he carried out similar work while with Manning, Maxwell, & Moore where he was engaged at various periods in engineering, sales and manufacturing. He resigned his position as chief engineer with a control valve manufacturer to organize his new company. Every effort will be made by an experienced personnel to supply the highest quality sales engineering and service, Ives said.

"Plant" Becomes a Division Of The Paraffine Companies

Plant Rubber and Asbestos Works, for many years a corporation wholly owned by The Paraffine Companies, Inc., on July 1 became the "Insulation Division" of Paraffine. Nationally known in the high temperature insulation field, "Plant" was established in 1898.

R. H. Chase, who will be the manager of Paraffine's Insulation Division, formerly was vice president and general manager of "Plant" with offices in San Francisco.

Insulations marketed by the "Pabco" Division will be identical in specifications and standards to those manufactured under the familiar "Plant" trademark, Chase explained. The change is

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simply a change in brand name and company name — from "Plant" to "Pabco."

J. C. Voiles, with "Plant" for 15 years, will assist Chase in San Francisco as regional manager for the Pacific Coast, and serve nationally as staff assistant in connection with Engineering functions.

%Proportioneers% to Exhibit

%Proportioneers, Inc.%, Providence, R. I., has announced it will exhibit its new loss-in-weight blender for liquid and dry materials together with the recently developed volumetric blender for lubricating oils, gasolines, solvents, etc., at the Third National Instrument Exhibit, Philadelphia, September 13-17. The equipment will be in continuous operation. R. P. Lowe and P. V. Crowther will be in charge.

Tube Turns Names Seiler As Executive Vice President

John G. Seiler has been elected executive vice president of Tube Turns, Inc., Louisville, Ky.

Seiler

Seiler became associated with Tube Turns, Inc., in 1930 and a year later he was appointed sales manager. He was made vice president at the beginning of World War II, and general sales manager in February, 1945.

Seiler is a member of the executive board of the American Supply & Machinery Manufacturers' Association; and a member of the American Welding Society, Drop Forgings Association, Army Ordnance Association, International Acetylene Association, American Standards Association, and the American Society for Metals.

DeLarzelere and Tudor Form LPG Equipment Company

Bob Tudor and F. P. DeLarzelere, Tulsa, have formed F. P. DeLarzelere Company to act as manufacturers' representative and agent on liquefied petroleum gas and oil field equipment.

Bob Tudor is well known in oil field circles having spent the majority of his business life in and around Tulsa, in the LPG oil field equipment business.

F. P. DeLarzelere was formerly president of Southern Gas & Equipment Company and is well known in LPG trade circles. He formerly was with Standard Oil Company (New Jersey) and has 25 years experience in the equipment business.

Heads Customer Relations

William R. Rinelli has been appointed director of Ansul Chemical Company's new customer relations department. This department will correlate the company's advertising, publicity, sales promotion and marketing.

Rinelli

Rinelli is well known in the refrigeration industry as the co-author of a number of technical papers. He is also one of the authors of "Refrigerating Data Book," published by the American Society of Refrigerating Engineers.

Prior to this new assignment, Rinelli was manager of Ansul's development division. A graduate of the University of Wisconsin in 1933, he has been with Ansul 13 years.

Instrument Firm Appoints Branch Office Managers

H. T. Sawyer, formerly manager of the company's Seattle office, has been promoted to manager of Bailey Meter Company's Buffalo office, replacing S. W. Nelson, deceased. Sawyer is a mechanical engineering graduate of Rensselaer Polytechnic Institute and has been associated with Bailey Meter Company since 1935.

K. E. Atwood, for the past 10 years in Bailey's Boston office, has been appointed Seattle office manager replacing Sawyer.

Bailey Meter also announced transfers from the Cleveland main office to branches as follows:

R. E. Erickson to Philadelphia, F. J. Ghezzi to Schenectady, F. D. Krusemark to Denver, J. R. Brennan to Buffalo, R. R. Beal and D. A. Gearhart to St. Paul and A. Martin to Atlanta. L. E. Bartel is being transferred from St. Louis to Kansas City.

Shoemake Gets Promotion

J. E. Shoemake has been named manager of refinery and pipe line equipment sales for Oil Well Supply Company's

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MODELS 150 AND 155

(155 is the angle type)

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Cast of tested all-bronze and equipped with phosphor bronze springs. Special disc will withstand temperatures up to 300 degrees oil heat. Construction permits quick opening and shockless closing of valve. Regulates any pressure up to 125 P. S. I. while line is under pressure. The advanced engineering of these valves eliminates wasteful leaks and costly equipment repairs. Model 150 is the horizontal type; Model 155 is the angle type. Sizes: 2", 2½", 3", and 4".

For additional details see Oilco Catalog No. 500—Write for your copy today

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Canada: Empire Brass Co., Ltd., London, Ont.

Gulf Coast Division, F. D. Smith, division manager for this U. S. Steel subsidiary, announced. Division headquarters are at Houston.

Joining "Oilwell" in October, 1945, at Shreveport, La., Shoemake went to Houston as district engineer, refinery equipment and pipe line sales in February, 1946.

Pennsylvania Forge Corp. Is Acquired by Tube Turns

Tube Turns, Inc., has acquired Pennsylvania Forge Corporation and George O. Boomer, president of Tube Turns, Inc., and its affiliate, The Girdler Corporation, will be chairman of the board of the Pennsylvania firm, which is one of the nation's best known and most highly regarded manufacturers of flanges and custom forgings. James S. Kerwin, president, and W. T. J. Huggard, secretary and treasurer, and other officers will continue in their present capacities, and there will be no change in the personnel of the various departments. The business of the new subsidiary will continue to be operated under the name of the Pennsylvania Forge Corporation. For several years Pennsylvania has been furnishing Tube Turns with flanges in all sizes.

The plant of the Pennsylvania Forge Corporation is in Tacomy, a suburb of Philadelphia.

Harold Anderson Promoted

Worthington Pump and Machinery Corporation has appointed Harold T. Anderson assistant to the general sales manager in charge of sales production relations, with headquarters at the Harrison (N. J.) works.

Anderson

Officials expect that this newly created office "will provide a smoother channel for expediting and advance the overall customer - relations program."

Anderson is a mechanical engineering graduate of Stevens Institute of Technology and has been employed by Worthington since 1924.

Foxboro Company Enlarges Its San Francisco Quarters

Having acquired the remaining space in the building which it occupies, at 266 Fremont Street, the San Francisco branch of The Foxboro Company is settled in its rearranged quarters, with practically double the working space previously available. The West Coast branch includes a shop fully equipped to assemble new Foxboro instruments and control valves, when time does not permit their shipment from the main factory in the East.

The San Francisco branch is headquarters of Harry B. Brooks, manager of the Pacific District, with supervision over all of Foxboro's branches west of the Rockies. Brooks is a veteran of 25 years' service with Foxboro.

Granco Dealers Named

Granberg Corporation of Oakland, Calif., has announced that Granco pumps

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and meters now have complete sales and service facilities throughout the South Atlantic States with the following authorized dealers: Modern Oil Equipment Company, Richmond, Va.; Petroleum Engineering, Baltimore, Md. Washington, D. C., Norfolk, Va., Greensboro, N. C., Columbia, S. C., Atlanta, Ga., and Jacksonville, Fla.; S. R. Hartgen & Company, Norfolk, Va.; Benton's Equipment & Supply Company, Miami, Fla.

Brown Adds to Service Staff

Another large increase in the branch and regional sales and service staffs of Brown Instrument Company—some 30-odd assignments—has been announced by W. H. Steinkamp, field sales manager of the industrial instrument division, Minneapolis-Honeywell Regulator Company.

The latest increase in the field staffs, said Steinkamp, reflects in size the additions which have been made twice yearly since 1945 and further confirms the growth of the company's business and its recently announced expansion of production facilities. These latest additions to the sales and service staffs numbered 33 men.

Sales Representatives Named

France Packing Company has appointed Thilenius Equipment Company, 303 E. Fourth Street, Tulsa, and George A. Krutilek, 1125 Texas Street, El Paso, Texas, as sales representatives in their local areas. These local sales offices will carry a stock of packing rings in cast iron, bronze and carbon-bakelite, compressor plate valves and segmental piston rings.

Fluor to Add Engineering Building

In this new Los Angeles engineering building for The Fluor Corporation, Ltd., the top floor alone will house more than 200 draftsmen. Called "one of the most advanced engineering buildings designed in recent years," and with about 62,000 square feet of floor space, it has such innovations as an overhanging second floor, a four-wing floor plan, continuous window areas, and aluminum window louvers for light control. The basement will contain a garage, storage, and blueprint facilities. Project engineers and their staffs will occupy the first floor.

The new building will be an addition to Fluor's main plant and home office, at 2500 South Atlantic, Los Angeles, and will permit the unification of the company's Los Angeles staff, which had overflowed into two downtown office buildings.

Pipe Line Engineering Named Alston Company Distributor

Alston Manufacturing Company, Livingston, Texas, was recently organized as a corporation, and the facilities of the plant enlarged. Alston Manufacturing Company formerly operated as "Alston Machine Shop." Victor and John Alston have joined with their father, H. D. Alston, as active members of the new organization.

Pipe Line Engineering & Equipment Company, Houston, of which Harry H. Tinch is president and general manager, has been appointed as exclusive distributor for the promotion and handling of sales of the Alston ratchet pipe cutter.

Forsberg Named President of Industrial Corrosion Control

Industrial Corrosion Control, Inc., has been recently incorporated under the direction of R. G. Forsberg, president. Forsberg also serves as president of Fenn-Ohio Industrial Sales Company, suppliers of industrial equipment and Pittsburgh representative for Industrial Corrosion Control, Inc. He was formerly

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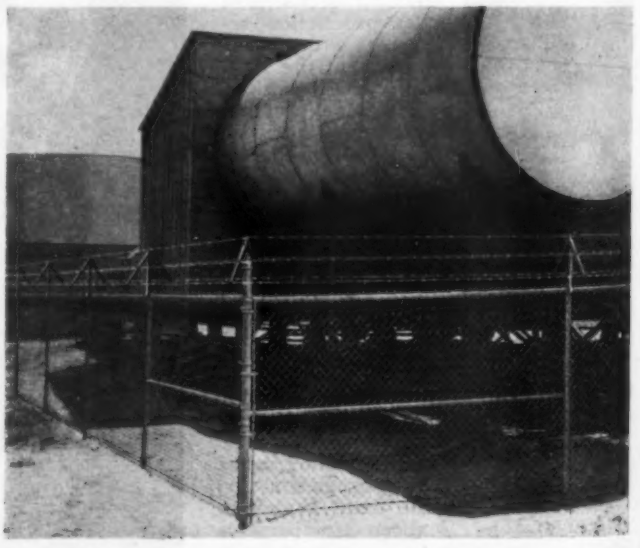

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General Offices: Denver, Colorado
Pacific Coast Sales: The California Wire Cloth Corporation, Oakland, Calif.
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associated with Jessop Steel Company as purchasing agent, and Timken Roller Bearing Company.

General sales offices for Industrial Corrosion Control will be in the Empire Building, Pittsburgh, with James D. Clokey, Jr., as sales manager. Clokey was formerly general manager of sales for Washington Steel Corporation, stainless steel specialists for Superior Steel Corporation and also associated with Carnegie Illinois Steel Corporation. Sales representatives for Industrial Corrosion Control are located in principal U. S. cities.

The plant, located at Neville Island, Pittsburgh, maintains facilities to line industrial equipment with vinyl plastisol, "a thermo setting plastic which has proven highly successful as a protective agent against corrosion."

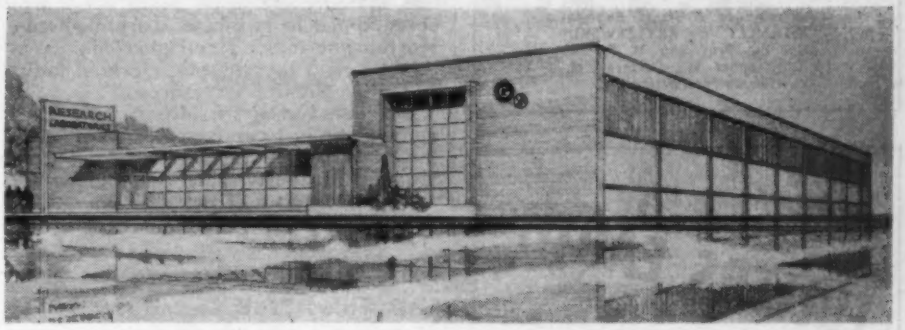
Atlantic Opens Sales Office

The Atlantic Refining Company on July 1 opened a sales office of its chemical products division in Chicago in the Chicago Title and Trust Building, 111 West Washington Street. Max H. Reynolds, with the company for 14 years, is in charge of the office. Reynolds has been associated with the company's research and development department and has spent most of his time on the sale of specialties and chemicals.

Innes Joins Jefferson

George L. Innes has joined the sales department of Jefferson Chemical Company, Inc., with headquarters at 30 Rockefeller Plaza, New York. He formerly was with Nopco Chemical Company, Harrison, N. J.

Edward Valves Starts New Building



Construction has been started on a new building to house the metallurgical, physical and chemical laboratories of Edward Valves, Inc., East Chicago, Ind., a subsidiary of Rockwell Manufacturing Company. The facilities will be used for research and development work on Edward and Nordstrom steel valves. The building will nearly triple the present Edward research facilities. Rooms especially built for the purpose will house stress analysis and creep testing equipment with controlled temperature and humidity, and a whole new section is being constructed for radiographic examination, doubling present capacity for this work. A section will be set aside for physical laboratory experimental setups, including pressure drop and flow research. Officials claim the Edward laboratories are the only laboratories in the world devoted exclusively to research on steel valves and the problems attendant to their manufacture and use.

Chicago Bridge & Iron Lets Contract for New Shop

The Chicago Bridge & Iron Company has let a contract to the American Bridge Company for an outside crane runway and shop building No. 2 at its new Salt Lake City, Utah, fabricating plant. Tanks and steel plate work are being fabricated in shop No. 1 which was completed in June. The new outside crane runway, 100 feet wide by 360 feet long, will be used to unload incoming steel and pass it into the shops.

No. 2 shop, 125 feet wide by 420 feet long, will be the same type construction as shop No. 1 and will be equipped with a 20-ton overhead bridge crane. The foundations for shop No. 2 will be started immediately and the building will be completed by Spring, 1949.

When shop No. 2 is complete, the new Salt Lake City plant will be a completely integrated unit, with facilities for fabricating practically all of the company's diversified line of prod-

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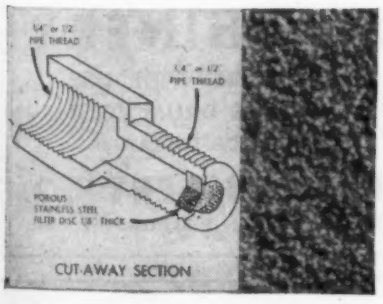

Equipoise POROUS Stainless Steel PRESSURE SNUBBERS

These new snubbers utilize a porous stainless steel disk as the primary element to eliminate pulsations. They can be used to protect all types of pressure sensitive instruments. Namely, pressure gauges; pressure indicating and recording controllers; diaphragm type differential meters; U-tube manometers; differential flow meters; pump governors; and diaphragm regulators. They also can be used as filters or as flow meters on small flows.

The porous disk is made in several standard Grades. Special grades made to suit application.

Grade "G" Air, gases, Butane, gasoline.
Grade "E" Water, kerosene, light oils, etc.
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ucts. Shop No. 1 is equipped to fabricate flat-bottom tanks, Horton Floating Roofs, reservoirs and other structures of this same general type. Shop No. 2 will be equipped to fabricate Hortonspheres, Hortonspheroids, Hemispheroids, Waterspheres, Vaporspheres, elevated tanks and other similar structures.

The new Chicago Bridge & Iron Company plant is located at 550 West 17th South Street in Salt Lake City. A. N. Hopper, formerly chief draftsman for the company at its Greenville, Pa., plant, is manager of the Salt Lake City plant.

Foster Wheeler Corporation Lists Sales Staff Changes

Foster Wheeler Corporation has announced three changes in its sales staff.

H. B. Wallace, Jr., has been appointed

Wallace

Downham

manager of steam sales for the corporation. He has been manager of the New England territory in Boston since his return from the armed service.

A. F. Downham, appointed manager of the New England territory succeeding Wallace, was formerly in the sales department of the Pittsburgh office.

Hardie

W. H. Hardie has become associated with the New York Sales office and will concentrate on the sales of steam generators, pulverizers, superheaters and related products.

Johnson Named Representative For Manning, Maxwell & Moore

C. F. "Cy" Johnson has recently joined Manning, Maxwell & Moore, Inc., whose main offices are in Bridgeport, Conn. Johnson will have his office in Houston and will function as special representative. He will also contact all phases of the oil industry with special emphasis on broadening the usefulness of the company's products in that industry with a view to adding to these products.

Johnson

Johnson, a Rice Institute graduate, has worked for Reed Roller Bit Company, Security Engineering Company and Watson-Stillman Company.

Girdler Picks Robert Wood As Executive Vice President

The Girdler Corporation, Louisville, Ky., has elected W. Roberts Wood executive vice president of the organization.

Wood

Wood was born in Louisville and received his degree of Bachelor of Chemistry at Cornell University. He was associated with DuPont in the East before joining The Girdler Corporation on November 1, 1929. He was placed in charge of the firm's Gas Processes Division on October 1, 1938, and on June 20, 1941, he was elected vice president. His most recent promotion came early last month.

Rimbach Appointed

Liquid Conditioning Corporation of Linden, N. J., has appointed T. N. Rimbach as district manager of Missouri and Arkansas, eastern Kansas and southern Illinois.

Rimbach, who entered the water conditioning field following his graduation as sanitary engineer at Massachusetts Institute of Technology in 1934, will have headquarters at 3903 Olive Street, St. Louis 8.

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